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IQ and the wealth of nations: How much reverse causality?

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ABSTRACT

This paper uses data from 130 IQ test administrations worldwide and employs regression analysis to try to quantify the impact of living conditions on average IQ scores in nationally-representative samples. The study emphasizes the possible role of conditions at or near the test-takers' time of birth. The paper finds that the impact of living conditions is of much smaller magnitude than is suggested by just looking at correlations between average IQ scores and socioeconomic indicators. After controlling for test-takers' region of ancestry, the impact of parasitic diseases on average IQ is found to be statistically insignificant when test results from the Caribbean are included in the analysis. As far as IQ and the wealth of nations are concerned, causality thus appears to run mostly from the former to the latter. The test-takers' region of ancestry dominates the regression results. While differences in average scores worldwide can thus be plausibly viewed as being influenced by genetic differences across world regions, it is also possible that score differences are influenced by regional differences in culture that are independent of genetic factors. Differences in average IQ across world regions may change in the years ahead insofar as the strength of Flynn effects may not be uniform, but some regional differences in average *g* levels seem likely to continue indefinitely.

1. Introduction

The presence or absence of intelligence can certainly affect the wealth of nations. In this context "reverse causality" is the idea that, other things equal, the wealth of nations affects intelligence levels as measured by, e.g., average IQ. Malnutrition, a lack of mental stimulation, poor sanitation, and a heavy disease burden offer quite plausible explanations for low IQ scores.

The specific questions addressed by this paper are as follows: (1) To what extent are differences in average IQ scores across countries caused by differences in living conditions?; (2) What is the relationship between average IQ and socioeconomic factors — per capita living standards, malnutrition, the disease burden, and education levels?; (3) How is average IQ affected by the presence of parasites?; and (4) After controlling for differences in living conditions, to what extent do average IQ differences reflect differences in ethnicity?

1.1. IQ, the wealth of nations, and the direction of causality: previous research

The principal analytical challenge facing any effort to study the relationship between IQ and the wealth of nations is to avoid simultaneity bias; any results obtained may be confounded by causality that runs in the opposite direction. Jones and Schneider (2006) obtained very robust formal results to support the notion that causality runs from IQ to the creation of wealth. Then, in a more informal way (Jones & Schneider, 2010), they downplayed the possible existence of significant reverse causality. On the other hand, Wicherts, Borsboom, and Dolan (2010a) asserted that "[n]ational IQ is just another indicator of development;" causality runs from wealth to IQ. They found good correlations between IQ and socioeconomic conditions, but understand very well that correlation does not necessarily indicate causation.

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In a related vein, the regression analysis by Hassall and Sherratt (2011) did not delve into the issue of causality. They found modest statistical links between IQ and socioeconomic factors — education, per capita gross domestic product (GDP), and malnutrition. Differences in parasite prevalence were the factor having the strongest relationship to the variation in IQ scores across countries, as had been found in a less sophisticated study by Eppig, Fincher, and Thornhill (2010). Hassall and Sherratt did not control for the test-takers' region of ancestry.[1]

Rindermann (2008) measured cognitive ability by combining the results of IQ assessments and achievement tests. Average scores on the two types of tests are highly correlated ($r > 0.80$), suggesting the existence of a common, country-level "cognitive competence" that scores on both types of tests reflect. This common factor is analogous to the *g*-factor of intelligence for individuals (Rindermann, 2007). Rindermann then conducted a path analysis and concluded that there is two-way causality between cognitive competence and living conditions, but that the causality running from the former to the latter is stronger than the reverse.

A hypothesis that is largely at odds with the idea of reverse causality is that test-takers' region of ancestry dominates the results. In the US, for example, ethnicity has a strong impact on average test scores even when income or socioeconomic status is held constant (Jencks & Phillips, 1998; Jensen, 1998, 404–405). The mean IQ result for blacks has been about one standard deviation (15 IQ points) below the one for Caucasians, despite the fact that, on average, African-Americans have as much as 22% European admixture (Zakharia et al., 2009). The performance gap is more pronounced for test items with higher *g*-loadings.

After controlling for socioeconomic status (SES), Jensen concluded that there is still a 12 point difference in average IQ scores between the two groups. And socioeconomic status itself is affected by IQ; the fact that blacks on average have lower SES is due in part to lower average IQ. On the *g*-loaded math SAT test, African-Americans from households with annual incomes of more than $100,000 (in terms of what US dollars were worth in 2012) have averaged lower scores than Asians and Caucasians from households with annual incomes of less than $16,000 (calculated from College Board data reported by La Griffe du Lion, 2000).

Hunt (2012) granted that genetic differences among groups of people could play a role in explaining the worldwide distribution of IQ scores, but based on correlations with socioeconomic indicators, he still suggested that living conditions play a major, perhaps dominating, role. Rindermann, Woodley, and Stratford (2012) offered another contribution to the discussion. As in Rindermann's previous work, the measure of cognitive ability combined the use of achievement tests and IQ scores (updated by Lynn & Meisenberg, 2010b). The authors undertook a path analysis and regressions and concluded that both genetic differences across groups of people and differences in living conditions help to account for the worldwide variation in test scores.

However, the path analysis did not allow for cognitive ability to affect living conditions, and since their main measure of living conditions—the UN's Human Development Index (HDI)—was contemporaneous with the measure of cognitive ability, coefficients from regressions that included the HDI variable were subject to simultaneity bias; one cannot safely infer causal magnitudes from them.

This paper uses regression analysis in an attempt to estimate the impact of living conditions on IQ scores. Data are used from 130 test administrations internationally. It is hypothesized that insofar as living conditions have an impact, early life experiences are critical. Thus, the regressions emphasize conditions at or near the time of birth. Sizable and enduring differences in average test scores across major ethnic groups are already present at age 3 (McKinley, 2009; Peoples, Fagan, & Drotar, 1995), with Peoples et al. finding that the result holds even after controlling for birth-order and the education level of the mother.

Early-life conditions may affect subsequent test scores. On the other hand, *current* IQ, while it can affect the production and acquisition of wealth, cannot affect *past* living conditions. By entering living conditions into the regressions in lagged form, a better understanding of the cause-and-effect relationship can hopefully be discerned. To better isolate the role of test-takers' region of ancestry, the regression analysis relies on test administrations in countries inhabited primarily by their indigenous peoples. The analysis leaves out test administrations conducted in places such as the United States, Canada, Australia, New Zealand, Israel, Singapore, and Taiwan.

Section 2 of the paper offers more discussion of the data and the explanatory variables used in the regressions. Section 3 outlines the regression results. Section 4 discusses the results in a broader context. Section 5 provides a conclusion and caveats.

2. Data and explanatory variables

2.1. International IQ scores

Lynn and Vanhanen (2002) made the first serious effort to compile IQ scores on a worldwide basis. Later, they updated and refined their collection of scores (Lynn & Vanhanen, 2006). These data have been the subject of extensive commentary (e.g., Barnett & Williams, 2004; Hunt & Wittmann, 2008; Rindermann & Ceci, 2009, 551). Meisenberg (2012a) provided further updates to the data, and Lynn and Vanhanen (2012) thus included many newer IQ studies in their compilation. For all of the data sets assembled by Meisenberg, Lynn, and Vanhanen, the authors adjusted the average IQ scores for Flynn effects.

This paper does not use the "national IQ" estimates of Lynn and Vanhanen, but it does use many of the test results referenced in their 2012 book. The times at which test-takers were born ranged from the 1950s to the 1990s.

In the case of sub-Saharan Africa, Wicherts, Dolan, and Maas (2010b) and Wicherts, Dolan, Carlson, and Maas (2010c) offered a thorough critique of Lynn and Vanhanen's criteria for including or excluding test administrations from the data set. Lynn and Meisenberg (2010a) replied to Wicherts et al. (2010b), and Lynn (2010) replied to Wicherts et al. (2010c).

[1] With reference to the discussion in Kanazawa (2008), the authors did include a variable for a country's distance from central Africa on the hypothesis that this distance indicates the extent to which people are likely to differ genetically from sub-Saharan Africans. However, two peoples – e.g., South Asians and Europeans, or Han Chinese and Australian aborigines – can be almost equally distant from central Africa, but very different from each other. The variable also fails to reflect the presence of nonindigenous peoples inside many countries. In short, the variable is not a good way to try to capture genetic differences among IQ test-takers.

For sub-Saharan Africa this paper uses test administrations of the Raven's Standard Progressive Matrices from Table 1 of Wicherts et al. (2010c). Lynn (2010) offered only a few overt criticisms of the test administrations referenced in the table. He objected to the inclusion of samples consisting of university students because they are not representative of a country's general population, and he objected to the inclusion of a study of test-takers who had to pay fees to the institution that they were attending; such test-takers would tend to be of higher-than-average socioeconomic status. This study thus excludes these test results as well as the result from a sample of illiterates.

Results are also excluded if there is no way to estimate the year when the test-takers were born, even on an average basis, or if the test-takers were born before 1950. United Nations statistics on socioeconomic conditions only go back to the 1950s — and then only for certain countries and indicators. Finally, test results are excluded in cases where the range of ages of the test-takers at a single administration exceeds 10 years (e.g., children and adults taking the same test). In such cases the idea of an "average" birth year loses its meaningfulness.

A common problem with school samples in sub-Saharan Africa (SSA) is the large number of children who are not enrolled at any institution. Wicherts et al., 2010c estimated an average IQ of 71 (on 1979 UK norms) for such children. The mean IQs for some school samples are therefore adjusted so that they are a weighted average of the mean score of the enrolled children and the estimated mean for the children not in school. Since the IQ scores for the paper's regressions are in terms of whole numbers, no adjustment is necessary in cases where school enrollments were high and/or the unadjusted score was already somewhat close to 71. United Nations statistics on school enrollments were employed, with linear interpolation used to fill in data gaps. The overall impact of the adjustments is that the unweighted mean of all the scores used from sub-Saharan Africa becomes 75, about two points lower than would otherwise have been the case. All of the test results were adjusted for Flynn effects by Wicherts et al.

The mean score for sub-Saharan Africa used here is higher than the median proposed by Lynn and Meisenberg (2010a) (median of 66 for the Standard Progressive Matrices), but lower than the mean proposed by Wicherts and his colleagues (82) for non-Raven's tests that have been used in sub-Saharan Africa (Wicherts et al., 2010b). Rindermann's (2013) review and analysis of the evidence on sub-Saharan African IQ concluded with a best-guess mean of 75.

For non-SSA test administrations referenced in Lynn and Vanhanen (2012), an effort is made to use only samples that are reasonably representative of the underlying population. Samples drawn only from residents of capital cities, other high-end cities, or specific socioeconomic classes are not employed. An effort is made not to judge representativeness on the basis of the average test score itself. While sympathy is shown for Wicherts et al.'s (2010b) criteria for excluding test results, the use of results obtained from sick children is not rejected out of hand insofar as some degree of ill-health is commonplace (i.e., representative) in some countries. On the other hand, the study excludes, which Wicherts et al. do not, studies focused on immigrants, who may be living in conditions very different from their region of ancestry.

The countries from which scores were obtained and the average results (on 1979 UK norms) are shown in Appendix A. Scores from Lynn and Vanhanen (2012) and from Wicherts et al. (2010c) that were not used are shown in Appendix B.

2.2. Regional clusters of indigenous peoples

Following Cavalli-Sforza, Menozzi, and Piazza (1994), indigenous peoples are defined according to residency before the year 1492. Thus, Europeans are not "indigenous" to the Americas, but Amerindians are. It is understood that much selective migration has occurred since 1492, and this migration may have affected the test scores and regression results to some degree.

The dependent variable in the paper's regressions is the average score at a test administration. To capture test-takers' region of ancestry, a set of dummy variables is used, with the principal question being where to set the boundaries of each region. Cavalli-Sforza et al.'s (1994) work on the geography of genes is used as a starting point, with due respect then being shown for more recent research in population genetics. The regions/genetic clusters for the study are thus: Northeast Asia, Europe, Southeast Asia, North Africa/South Asia, sub-Saharan Africa, the Americas, and Pacific Islands. It is understood that genetic variation exists within as well as across these regions, India by itself having amazing genetic diversity.

An issue for this study is whether test results seem thereby to be significantly affected. To cite examples of the research that is relevant for this study: in sub-Saharan Africa 14 genetic subclusters have been identified (Tishkoff et al., 2009), but aside from studies of the San ("Bushmen") and Pygmies, there is no clear evidence at this point for distinctive average IQ scores from one subcluster to another. American blacks are most strongly related to a subcluster for an area that includes Nigeria and Cameroon. Caribbean blacks also have strong West African links.

Southern Spain has had substantial gene inflow from Africa, but overall, its genetic profile and test results are very European in nature. Italy's story is somewhat similar, but also features much gene inflow from Southeastern Europe and Turkey, with impacts on, e.g., Sicily and Tuscany. Rindermann et al. (2012) found that the haplogroups whose presence is strongly related to cognitive ability across countries are also strongly related to test scores across the various parts of Spain and Italy.

Bulgaria borders on Turkey, but is, genetically speaking, mostly European in nature (Karachanak et al., 2011, 2012). Greece is, genetically speaking, more like Turkey than Bulgaria is. Slovenia and Romania are very European, genetically speaking. Guatemala is estimated to be about three-quarters Amerindian and one-quarter ethnically European. Bolivia is found to have a similar profile.

On the other side of the Pacific Ocean, Cavalli Sforza et al. concluded that the Huai River in China has served as a dividing line between a genetic cluster of Northeast Asians versus one of Southeast Asians. However, more recent research (Wen et al., 2004; Xue et al., 2008) has found greater genetic unity among the Chinese people. The Han Chinese originated from tribes in the Yellow River valley, north of the Huai River, but Han people, especially males, migrated to southern China in large numbers and had children there. Both northern and southern Chinese are thus classified, at least at the outset, as Northeast Asians here. Test scores also seem to be similar in the two parts of China.

Indonesia is classified in this paper's analysis as thoroughly Southeast Asian, but Thailand, Malaysia, and other countries in the region present a more ambiguous picture. Malaysia has a sizable percentage of ethnic Chinese and also has some East Indians. On the other hand, Malays are a clear majority, Malay is the main language, and the dominant culture is Malay. At the outset of this study, Malaysia is classified as two-thirds Southeast Asian and one-third Northeast Asian. Thais are a clear majority of the population of Thailand, but there is a significant Chinese presence. Thailand is classified as three-quarters Southeast Asian and one-quarter Northeast Asian.

Greece is classified at the outset as half European and half North African/South Asian. Bulgaria is classified as three-quarters European and one-quarter North African/South Asian. Turkey is classified as three-quarters North African/South Asian and one-quarter European. Malta is classified as three-quarters European and one-quarter North African/South Asian. Sensitivity analysis is performed to see if assigning different weights in the above cases makes for a serious difference in the regression results.

2.3. Living conditions

Living conditions are captured, first, by real per capita GDP (Penn World Tables, Version 7.0, "chain series," reference year of 2005 (Heston, Summers, & Aten, 2011)),[2] measured for the year in which test-takers were born. While per capita GDP measured in terms of real purchasing power offers a standard characterization of average living standards, it may not capture very well all of the conditions that might affect IQ. South Africa, for example, has had higher per capita GDP than Tonga, but more malnutrition, which can affect brain size and functioning. The presence of disease is also relevant for the functioning of the brain, but may only be loosely correlated with per capita GDP.

The United Nations collects data on several indicators of socioeconomic conditions – the percent of households consuming iodized salt, the percent of babies being breastfed, the percent of children enrolled in school, etc. – but data for many of the indicators are very incomplete. Reasonable data for the under-five mortality rate, on the other hand, are available in most cases back to 1960, and earlier in some cases. Where possible, a very recent data series (United Nations Children's Fund, 2011) for under-five mortality is used. A year-by-year time series can then be constructed for the countries that contributed IQ scores to the data set. Gaps in the data were filled in via geometric imputation with reference to the published statistics for the beginning of each decade.

A correlation matrix pertaining to UN socioeconomic data published in 2002 (United Nations Children's Fund, 2002) shows that the under-five mortality rate is very strongly related to the percent of age-eligible children enrolled in primary school (Pearson correlation coefficient of −0.82, N = 96). It is also strongly related to the rate of malnutrition (coefficient of 0.67, N = 96), measured as the percent of children under age five whose height has been moderately or severely stunted. The birth-year under-five mortality rate is thus entered into many of the regressions as an indicator of living conditions apart from per capita GDP.

While the under-five mortality rate is very strongly related to primary school enrollments, Barro and Lee compiled a time-series for the average number of years of schooling completed by people in various countries (Barro-Lee Educational Attainment Dataset, 2011). Barro–Lee data for adults, age 25 or older, are entered into many of this paper's regressions. The birth-year value for the variable used provides an indication of the general educational milieu in which IQ test-takers have grown up — e.g., the vocabulary of the adults around them.[3]

Finally, since stunting data are not available for many countries, the paper uses as a malnutrition variable the nutrition deficiency index of the World Health Organisation (2004). The malnutrition data are only available on a cross-sectional basis, and it is understood that the variable has its limitations. Moreover, any regression coefficient for the variable is subject to simultaneity bias; malnutrition may affect IQ, but IQ may affect living conditions, including the rate of malnutrition. Nevertheless, it is of interest to get an idea of the magnitude of the statistical association between IQ and malnutrition after controlling for the other variables.

We thus have: IQ = f (region of ancestry, per capita GDP, chance of dying by age 5, years of education, malnutrition), where the included variables for living conditions reflect general living standards, the extent of disease and malnutrition, and the level of education. Estimating the impact of parasites on IQ scores poses special challenges and is taken up in two additional subsections of the paper.

3. Regressions vs. correlations

3.1. Middle East oil kingdoms: high per capita GDP, moderately-low average IQ

The data set contains especially high per capita GDPs for the average birth years of test-takers in Kuwait ($43,000 for one group of test-takers and $47,000 for another) and Qatar ($67,000 for one group and $84,000 for another). Of course, much of the income produced in Kuwait, Qatar, and other oil kingdoms goes to ruling elites, raising a concern that the GDP statistics do not provide a good picture of the living standards of ordinary people.

If the nine observations for oil kingdoms are included, the correlation coefficient between average IQ and birth-year per capita GDP is just 0.24 (N = 130). If the observations for oil kingdoms are deleted, the correlation coefficient is 0.60.

[2] In a few cases the Penn World Tables (PWT), Version 7.0 do not provide per capita GDP estimates for a particular country for particular years, but estimates are available from an earlier version of the PWT or from Maddison (2010). In such cases, an alternative per capita GDP estimate is used. This alternative estimate is divided by the US per capita GDP estimate in the alternative data set and multiplied by 100 to calculate the other country's per capita GDP as a percent of the US. Then we take the US per capita GDP estimate in PWT 7.0 and use the percentage calculated above to impute a PWT 7.0 per-capita-GDP figure for the other country and year in question.

[3] It might be argued that the relevant variable is the education received as of the test date. However, many IQ tests are given to children, e.g., 10 year-olds. Even if the average number of years of education ultimately completed by people in one country is much higher than the average in another country, the 10 year-olds in the two countries may have received the same number of years of education before the test: e.g., 5 years. Of course, the quality of the schooling is also an issue.

Table 1
Bivariate correlations for IQ and living conditions.

	IQ	GDP	Malnutrition	Education	Under-5 mortality
IQ	1.00				
GDP	0.24	1.00			
Malnutrition	−0.72	−0.51	1.00		
Education	0.66	0.39	−0.67	1.00	
Under-5 mortality	−0.65	−0.50	0.70	−0.80	1.00

Table 1 shows a correlation matrix for the data on IQ, per capita GDP, the degree of malnutrition, education, and the under-five mortality rate.

Thus, average IQ has a strong negative correlation with malnutrition and under-five mortality. It has a strong, positive correlation with education, but the correlation with per capita GDP is strong only if the observations for oil kingdoms are deleted.

3.2. Powerful regional influences

The regression analysis for average IQ is begun by using as explanatory variables only a constant term and the dummy variables for region of ancestry. These variables alone account for 86% of the variation in all of the average test scores (N = 130), with the Northeast Asian scores centering on 105, followed by Europe (97), Pacific Islands (85), Southeast Asia (85), North Africa/South Asia (83), Amerindians (78), and sub-Saharan Africa (75). All of the regression coefficients are significant at a 1% level. For scores with a mixed-race influence, the nonindigenous factor has been statistically stripped out above so as to show only the indigenous component.

For the present paper there are only two scores involving Amerindians, one of them a score of 79 from Guatemala (for mixed-race "ladinos" and Amerindians combined) on the Draw-a-Man test, and the other a score of 87 from Bolivia. Since the scores are for countries classified as one-quarter European, the Amerindian influence is viewed statistically in a very negative fashion.

3.3. The impact of living conditions on average IQ

3.3.1. Alternative specifications for living conditions

Control variables for living conditions are now introduced: per capita GDP, the under-five mortality rate, education, and the degree of malnutrition. An additional dummy variable is inserted to isolate the nine observations for oil kingdoms. The variable takes on a value of '1' for these observations and '0' otherwise. The kingdoms refer to Bahrain, Kuwait, Libya, Oman, Qatar, and the United Arab Emirates. Saudi Arabia is not included in this group for a data point pertaining to the period of time before the 1973 run-up in oil prices.

Since the variables for living conditions are strongly correlated with one another in most respects, results may be influenced by multicollinearity or suppressor effects. A stepwise, forward selection approach is used for some sets of regressions and a backward elimination approach is used for others. The results are explicated and their trustworthiness is then discussed.

For either forward selection or backward elimination, the malnutrition variable stands out. In regressions (N = 129, no malnutrition data for the Palestinian Territories) where there is only one variable representing living conditions, whether it be malnutrition, per capita GDP, education, or under-five mortality, the coefficient on the variable is always statistically significant at least at a 10% level. However, the coefficient for the malnutrition variable is also statistically significant in the presence of *any* combination of the other variables. On the other hand, the coefficient for *none* of the other variables is statistically significant in the presence of the malnutrition variable. A regression with just the malnutrition variable present to reflect living conditions also yields the highest adjusted R^2.

The coefficients for all of the regional dummy variables are significant at a 1% level in every case. Table 2 shows coefficients for the preferred model specification. The coefficient for the oil kingdom dummy variable invariably has a negative sign, suggesting that average IQ levels in the oil kingdoms are slightly lower than their living conditions would predict, but in no case is the coefficient statistically significant.

The coefficients for the regional dummy variables indicate that, even after controlling for living conditions, there is a 27.2 point difference in average IQ between Northeast Asians and sub-Saharan Africans. There is an 18.7 point difference between Europeans and sub-Saharan Africans. There is an 8.5 point difference between Northeast Asians and Europeans.

3.3.2. Interpreting the regression coefficients for living conditions

The variables for living conditions have only modest effects on average IQ. Consider the following scores: China (103), Switzerland (101), Kuwait (86), Pakistan (84), and Nigeria (79), which are quite representative of the IQ tests administered in those countries. The data on the living conditions for the above scores are shown in Table 3.

For the data shown, Nigeria obviously looks handicapped. However, Switzerland was *50 times* richer than China in terms of real purchasing power. The Chinese were also more poorly nourished and carried a heavier disease burden. In addition, the average number of years of schooling in Switzerland was more than twice as high as in China. Nevertheless, the Chinese registered slightly higher IQs.

Table 2
Impacts on average IQ (N = 129, Palestinian Territories excluded), stepwise regression selection via forward selection or backward elimination.

Variable	Coefficient
Log malnutrition	−1.37*
Northeast Asians (vs. Europeans)	+8.5**
Pacific Islanders (vs. Europeans)	−9.5**
Southeast Asians (vs. Europeans)	−9.6**
North Africans/South Asians (vs. Europeans)	−11.5**
Amerindians (vs. Europeans)	−15.0**
Sub-Saharan Africans (vs. Europeans)	−18.7**
R^2	0.86

* Statistically significant at a 5% level.
** Statistically significant at a 1% level.

Table 3
Living conditions for selected IQ scores.

Country	Per capita GDP	Malnutrition (WHO Index)	Under-5 mortality (per 1000 live births)
Switzerland	$31,228	56	9
Kuwait	$43,071	147	14
China	$617	253	67
Pakistan	$1021	575	176
Nigeria	$1355	836	269

Kuwait's per capita GDP was even higher than Switzerland's. Its nutritional standards were clearly much better than China's, and its disease burden was considerably lower. Yet, its average intelligence level appears to be much lower as well — 17 IQ points lower. In fact, it is not much different than the level for Pakistan, which has had far more miserable living conditions.

The reported IQs are difficult to explain unless the test-takers' region of ancestry is given considerable weight. According to the regression results, the difference in nutrition levels is related to just 4 points of the difference in the scores between Switzerland and Nigeria, and as noted earlier, the malnutrition variable does not enter the regressions in a lagged fashion. Thus, one cannot automatically conclude that there is a cause-and-effect relationship of 4 points that runs from malnutrition to average IQ. There could possibly be causality going from IQ to nutrition levels as well.

In summary, the regressions do not support the view that differences in living conditions account for a major part of the differences in average IQ scores. Relatedly, Rindermann, Falkenhayn, and Baumeister (under review) studied elite samples – healthy, well-nourished, comfortable, college-educated, and computer-literate – of Nigerians and Germans and introduced the groups to the Advanced Progressive Matrices before testing them on part of it. The conclusion was that, having controlled for the backgrounds of the test-takers, there is indeed a 20-point – or greater – difference in the average IQs of their respective populations, *independent* of educational levels and living standards in the two countries.

3.3.3. Spatial autocorrelation

We have been talking with reference to a large convenience sample of average test scores. Classical least-squares regression analysis assumes that data points are independent of one another. Hassall and Sherratt (2011) questioned this assumption for the present type of study, with the suspicion being that some of the regression results are contaminated by spatial autocorrelation. Such autocorrelation refers to a tendency for variables to cluster geographically. In addition, data points may be defined in accordance with rather arbitrary national boundaries; having numerous small countries in a region can thus artificially inflate sample sizes, correlation magnitudes, and statistical significances. In the present study, for example, 44 of the 130 average test scores are from Europe, although Europe has long had well under 20% of the world's population.

The Moran's I coefficient, which is typically used to test for spatial autocorrelation, does indicate the presence of non-random elements in the sample used for the paper. However, after using standard adjustment methods (e.g., Rindermann et al., 2012), the regression results are unaffected, regardless of whether a forward selection or backward elimination process is used. There is again only modest reverse causality.

3.3.4. Is parasite prevalence the critical 'X' factor affecting IQ?

The question naturally arises as to whether some omitted factor ('X') has a large-magnitude effect on average IQ. Any such factor cannot be highly correlated with per capita GDP, the under-five mortality rate, the degree of malnutrition, average years of education completed, or any conceivable linear combination of the above, or else its influence would already have been picked up.

This paper has made use of the under-five mortality rate in many regressions because the United Nations has collected statistics on it going back to the 1950s, and because it is highly correlated with other socioeconomic indicators, some of which have very incomplete data. It is a good general indicator of living conditions apart from per capita GDP. However, Eppig et al. (2010) have made a strong case for considering parasite prevalence as a separate, health-related factor with a sizable impact on IQ, especially in sub-Saharan Africa. It represents an important part of the disease burden in many countries, whether or not children die from it.

There are two main questions about the research to date on parasite prevalence. First, while the measure used – "disability-adjusted life-years lost from infectious and parasitic diseases" (DALY) – does appear to be related to IQ ($r = -0.63$ for this paper's primary data set), neither the paper by Eppig et al. nor the one by Hassall and Sharratt provides evidence on causality. To some extent, it may be that a pervasive presence of parasites is the effect of low IQ rather than a cause. Thus, it can be argued that Nigerians (average IQ < 80) failed to deal effectively with parasites, whereas highly-intelligent people in Singapore (average IQ > 100) implemented successful eradication programs.

Second, Eppig et al. acknowledge that they cannot very well account for low IQ scores in the Caribbean, which has far less parasite prevalence than is found in sub-Saharan Africa. Even Haiti has less than half the parasite prevalence of South Africa, and less than one fifth of the parasite prevalence in Zimbabwe. Table 4 shows the extent of parasite prevalence in selected countries.

A statistical problem concerning parasite prevalence is that, while the World Health Organisation (2004) has fairly recent data on it for many countries, there is scant quantitative evidence going back several decades. But the now-distant past is when many of the brains tested for the Lynn–Vanhanen compilation were developing. It is therefore awkward to claim that causality has been shown to go from parasites to IQ when the parasite data were collected well after most of the IQ tests were taken.

To try to determine an order of magnitude for the possible relevance of parasites, we first include in IQ regressions the variable used by Eppig et al. and by Hassall and Sharratt. The regressions also have the regional dummy variables and various combinations of the other variables for living conditions. A logarithmic form for the parasite variable offers slightly stronger results than a linear form.

If the parasite variable is the only variable in the regression representing living conditions ($N = 129$), the coefficient for the variable is statistically significant at a 5% level. The coefficient (-0.83) suggests that Nigeria's high parasite load is associated with a reduction in average IQ of about 4 points vis-à-vis Switzerland. However, if the malnutrition variable is also entered into the regression, its own coefficient is statistically significant (once again), but the one for the parasite variable is not. Making adjustments for spatial autocorrelation does not change these results, assuming stepwise selection. The adjusted R^2 is higher if the parasite variable is simply left out.

3.3.5. Inclusion of average IQ scores from the Caribbean

We now add to the data set average IQ scores for predominantly black countries in the Caribbean. These scores were not originally included because ethnic sub-Saharans are not indigenous to the Americas. The first IQ scores that are candidates for inclusion are Caribbean scores from Lynn and Vanhanen (2012). However, it appears that Lynn and Vanhanen badly mischaracterized the available test results for Jamaica and were unaware of studies done in Haiti (Jason Malloy, www.humanvarieties.org, 24 January 2013c and 1 March 2013a). In fact, there are now many available scores for Jamaica other than those mentioned in Lynn and Vanhanen's work. The median value of the scores from reasonably representative samples is 79. Their unweighted mean is 78. There are two alternative, very divergent scores available for Haiti (mean value of 81). Lynn and Vanhanen do have usable scores from Barbados (80), Dominica (67), St. Lucia (62), and St. Vincent (71), plus one usable score from Jamaica (71) (included by Malloy). See Appendix C.

If we substitute in the alternative scores for Jamaica and the two scores for Haiti, but include the other Caribbean scores from Lynn and Vanhanen, the correlation between parasite prevalence and IQ changes from −0.63 to −0.49. In the regressions (N = 151), *the coefficient for the parasite variable becomes statistically insignificant in every case*, regardless of whether adjustments are made for spatial autocorrelation.

The explanation for this result is quite simple: the unweighted mean of all the scores used from the Caribbean is 76, almost the same as the mean of the scores used from sub-Saharan Africa, despite the great difference in parasite prevalence in the two locations. Thus, with Caribbean scores included, the regression analysis regards parasite prevalence as an unimportant factor in the determination of average IQ. Test-takers' region of ancestry again dominates the results. China has just as heavy a parasite burden as Dominica, but far higher average IQ. Generally speaking, elite Nigerians who do not have parasitic diseases and do not suffer from malnutrition simply do not have IQs that are close to those of elite Germans (Rindermann et al., under review).

The evidence on average IQ levels in the Caribbean remains open to discussion, just as the evidence for sub-Saharan Africa remains somewhat unsettled. Ethnic sub-Saharans in the Bahamas and Bermuda may get higher average scores than Jamaicans, Haitians, or Barbadians, but it will take a while to more clearly establish the average IQ levels for blacks in these countries.

Table 4
Parasite prevalence in selected countries: disability-adjusted life-years (DALY) lost from infectious and parasitic diseases (World Health Organisation, 2004).

Country	DALY
China	985.88
Japan	164.38
Switzerland	181.55
UK	187.20
India	4753.22
Indonesia	3099.10
Congo	15033.42
Nigeria	17976.10
South Africa	22646.43
Zimbabwe	57454.07
Barbados	1371.81
Dominica	950.01
Haiti	10121.21
Jamaica	2009.08

4. Discussion

4.1. Elaboration of the study's findings

It is important to note the difference between an impact on individual IQ and an impact on average IQ. For example, a study in Barbados found a 15 point IQ difference between children who had been moderately or severely malnourished and children who had not (Galler, Ramsey, Solimano, Lowell, & Mason, 1983; Galler, Ramsey, & Forde, 1986), a rather dramatic-looking impact. Sixteen and a half percent of the Barbadian children were classified as moderately or severely malnourished. Putting aside issues of causality, malnutrition was thus associated with a reduction in average IQ of $(15 \times 0.165) = 2.475$ points, which does not look as dramatic as the 15 point reduction for malnourished individuals. In any event, even the average IQ of the well-nourished Barbadians was less than 83.

The regression results for reverse causality are not much affected by changes in the regional boundaries. For example, if China is classified as one-quarter Southeast Asian, or if Italy is classified as one-quarter North African/South Asian, the explanatory power of the regressions is slightly weaker. The overall conclusion is that it is very plausible to argue that regional differences in average IQ scores are much affected by genetic differences across groups of people, but it is also possible that they are affected by cultural differences across regions that are independent of genetic factors. The search for an ‘X’ factor continues.

4.2. Related literature in behavioral genetics

Across individuals, studies of identical twins reared apart have typically found intelligence to be greatly influenced by genetic factors (e.g., Bouchard, 2004, Table 1), at least in adulthood. Explanations for racial differences in average IQ scores have been a more contentious matter. Transracial adoption studies offer a possible way to separate the effects of genes from culture. If, near the time of birth, representative children of one race are adopted into the culture of another race, data can be collected to see whether the average IQ of the children turns out to be close to the average of other members of their race, or whether it turns out to be closer to the average for other members of their adoptive culture.

A problem with most such studies is that IQs are assessed only during childhood, whereas it is axiomatic in the behavioral genetics literature that the influence of heredity is not fully established until later on. One can therefore find transracial adoption studies of children that support the hypothesis of heredity-based differences in intelligence across races (Rushton & Jensen, 2010), but one can cite other studies that do not support such a view (Nisbett, 1998). Ideally, those under study would be tested at an older age in addition to being tested as children.

In the famous case of Weinberg, Scarr, and Waldman (1992), black children adopted at an early age into white families had reasonably good IQ scores when tested at age 7, but scored much closer to the mean for all black children, both adopted and unadopted, at the age of 17. Mixed-race adoptees ended up scoring part-way between the average scores for the white adoptees and the black adoptees, respectively, even in cases where the adopting parents mistakenly believed that the mixed-race children had two black biological parents.

It is also worth mentioning that, insofar as a child's socioeconomic status (SES) and home environment may be improved by adoption, the increase in IQ that occurs at least on a temporary basis does not occur on the *g*-factor of intelligence (Jensen, 1997), whereas the IQ difference between high-SES and low-SES children raised by their biological parents *is* on the *g*-factor. To the extent that measured IQs are related to reaction times, brain-wave amplitude, nerve conduction velocity, school performance, and job performance, the correlations are strongest for highly *g*-loaded tests (Jensen, 1998).

Jason Malloy (www.humanvarieties.org, 16 February 2013b) has unearthed a previously uncited study (Gildea, 1992) of Korean children adopted into white American households that is of interest for both the IQ scores reported and the data collected on home environments. The Korean children were 8–12 years old and had an average IQ score from 1/3 to 1 standard deviation higher on the Wechsler intelligence scales (WISC) than groups of white adopted children who also had been tested on the Wechsler scales. Moreover, the home environments of the Korean adoptees were found to be poor predictors of academic achievement. There was actually a negative correlation between socioeconomic status and achievement scores within the Korean sample.

Gildea raises the possibility that the performance of the Korean adoptees vis-à-vis white adoptees might be explained by genetic factors, but one cannot be confident about the representativeness of the sample ($N = 43$). In short, some of the evidence from transracial adoption studies is provocative, but if one asks whether this literature supports a hypothesis of a genetic basis for racial differences in average intelligence, the answer is that, on its own, the research cannot be considered conclusive. The transracial adoption evidence must be reviewed together with evidence regarding forward and backward digit spans, brain size, reaction times, and other respects in which, on average, races differ (Nisbett, 2009; Rushton & Jensen, 2010).

5. Conclusion and caveats

5.1. Summary and perspective

This study finds that reverse causality is of much smaller magnitude than is often assumed by just looking at correlations between average IQ scores and socioeconomic conditions. As far as IQ and the wealth of nations are concerned, causality appears to run mostly from the former to the latter. Region of ancestry is the main influence on the regression results — and not simply as a proxy for impacts coming from malnutrition, parasites, or other factors in the social or natural environment.

The results are clearest in cases where countries have very different living conditions than other countries in the same world region. China has had far worse living conditions than Japan or South Korea, but average IQ scores that are close to those of its neighbors. Taiwanese born in the early 1940s into poor conditions on the island of Taiwan or in Mainland China recorded an average IQ of 102 (Rodd, 1959). Kuwait and other oil kingdoms have had much better living conditions than other countries in the North Africa/South Asia region, but test results that are not appreciably different.

Endowed with great diamond wealth, Botswana has been touted as a positive example of economic development in sub-Saharan Africa. For young Botswanan adults born after 1985, average years of schooling exceed the mean for young adults in Turkey, and are only slightly below the average for similarly-aged British nationals (Barro-Lee Educational Attainment Dataset, 2011). Yet, a reasonably representative sample of Botswanans, aged 17–20, all born in the late 1980s or early 1990s, received an average IQ score of just 71 on the Standard Progressive Matrices (SPM). Achievements scores have also indicated an average IQ in the 70s. Impoverished Mongols born after 1990 scored 29 points higher on the SPM (Lynn & Vanhanen, 2012).

Some caveats are in order. The study began with a large convenience sample, with any biases that it may contain. While Lynn and Vanhanen have been questioned about their characterization of average IQ in sub-Saharan Africa (SSA), questions might be raised as well about many non-SSA test administrations that have or have not been referenced in their work. An ongoing re-evaluation of the data for all world regions would be desirable.

Large and highly significant regional differences in average IQ scores may well reflect the influence of regional genetic factors. It is also possible that scores are affected by regional differences in culture that are independent of genetic considerations, although the various versions of the Progressive Matrices represent efforts to produce tests that are culture-reduced. Transracial adoption studies can shed light on the possible contribution of genetic factors, but other lines of research must be considered as well.

5.2. The Flynn effect and the outlook for international differences

To account for the Flynn effect, this paper has relied on conventional adjustments to IQ scores made with respect to tests that were, in most cases, administered many years ago. Wicherts et al. (2010c) have questioned whether the Flynn effect has operated in sub-Saharan Africa in the same way as in other places, but an analysis of all of the African IQ data in the various papers authored by Wicherts and associates shows nothing unusual. The average scores using conventional Flynn adjustments have essentially a zero time trend from the 1930s to the 2000s. If the Flynn effect had not yet begun in Africa, we would expect to see a negative trend in the Flynn-adjusted scores. If an accelerated Flynn effect were occurring, we would see a strongly positive trend.

Rindermann's (2013) review of sub-Saharan African scores refers to an accelerated Flynn effect found by Daley, Whaley, Sigman, Espinosa, and Neuman (2003) in rural Kenya, but a standardization of the Colored Progressive Matrices (CPM) for Kenya from about the same time (Costenbader & Ngari, 2000) arrived at a much more mundane result: an average IQ that was 8–9 points lower (Wicherts et al., 2010c; Lynn & Vanhanen, 2012) than the estimate by Daley et al. The CPM standardization thus implies a more mundane Flynn effect as well. Meisenberg, Lawless, Lambert, and Newton's (2005) estimates for Dominica support the existence of accelerated increases in average IQ, but Khaleefa, Abdelwahid, Abdulradi, and Lynn's (2008) results for Sudan do not.

In light of recent evidence that the Flynn effect has ended in Northern Europe and a few other places, it is indeed possible that there could now be a narrowing underway of differences in average IQ between many developed and less developed countries (Meisenberg, 2012b), but note that, in light of its communist legacy, China's average living standards are still well below Mexico's. Assuming that the Flynn effect is somehow linked to ongoing economic development, won't China's advantage in average IQ over Northern Europe now *widen*?

Moreover, the Flynn effect does not appear to involve an increase in the *g*-factor of intelligence (Te Nijenhuis, 2013). Rushton and Jensen's (2003) comparison of black Zimbabweans and white Americans found that much of the difference in performance between the two groups on subtests of the WISC-R is attributable to differences in *g*. The discussion in Wicherts et al. (2010c) questions whether the available African IQ scores are as indicative of *g* levels as scores are in Western countries, but still gives credence to the existence of substantial differences in average *g* between sub-Saharan Africa and other world regions. This paper thus concludes that, while changes in average-IQ differences seem inevitable, some regional differences in average g levels seem likely to continue indefinitely.

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Appendix A

Listed below are the average IQ scores of the main data set (N = 130), where 100 refers to the average score received by British test-takers in 1979. All scores have been adjusted for Flynn effects. Scores were drawn only from countries populated primarily by their indigenous peoples. For Nigeria, scores are shown after adjusting for school enrollments; the unadjusted scores are in parentheses.

Austria	99									
Bahrain	81									
Bangladesh	81									
Bolivia	87									
Bosnia	94									
Bulgaria	91									
China	101	103	107							
Congo (Brazzaville)	72									
Denmark	97									
Egypt	81	83								
Estonia	98									
Fiji	85									
Finland	98									
France	97	98	102							
Germany	99									
Greece	88	89	92	97						
Guatemala	79									
Hungary	95									
Iceland	101									
India	78	79	80	81	82	82	84	86	88	88
Indonesia	86	87								
Iran	80	83	89							
Ireland	87	91	92	93						
Italy	90	95	95	99	103					
Japan	101	102	103	103	104	105	106	107	107	112
Jordan	82	84								
Korea	100	103	109	113						
Kuwait	86	87								
Libya	85									
Lithuania	92	96								
Malaysia (* = Malays)	85*	92								

(*continued on next page*)

Malta	97						
Netherlands	99	99	101				
Nigeria	69	72	75(77)	79(83)	80(85)	82(85)	82(88)
Oman	81	87					
Pakistan	82	84	84				
Palestine	86						
Papua New Guinea	83						
Poland	90	92	102				
Portugal	88						
Qatar	78	88					
Romania	94						
Saudi Arabia	80						
Serbia	98						
Slovakia	98						
Slovenia	95	96	99	103			
South Africa (blacks)	68	75	75	75			
Spain	97	102					
Syria	83						
Sweden	97	99					
Switzerland	101	104					
Thailand	87	91					
Tonga	86						
Tunisia	84						
Turkey	84	87	90	96			
Ukraine	95						
United Arab Emirates	83						
United Kingdom	100						
Yemen	81	85					

Sources: Lynn and Vanhanen (2012); Wicherts et al. (2010c, Table 1).

Appendix B

Listed below are average IQ scores for test administrations from Lynn and Vanhanen (2012) and from Wicherts et al. (2010c, Table 1) that were not used for the paper's regression analysis. As with Appendix A, the scores in Appendix B refer only to countries populated primarily by their indigenous peoples.

From Lynn and Vanhanen (2012) (outside of sub-Saharan Africa) — Armenia: 92; Austria: 101; Belgium: 99, 99, 103; Bulgaria: 94; China: 103, 104, 107, 107, 109, 113; Croatia: 90, 99, 104; Czech Republic: 96, 98, 100; Denmark: 99; Egypt: 77; Estonia: 100; Finland: 96; France: 94, 101; Germany: 90, 97, 97, 99, 99, 101, 105; Greece: 95; Greenland: 91; Hungary: 98; India: 80, 81, 82, 87; Indonesia: 87, 87; Iran: 84; Iraq: 87, 87; Ireland: 91, 92, 95, 96, 97, 97; Italy: 76, 102, 103; Japan: 100, 102, 102, 102, 103, 104, 105, 105, 105, 108, 109, 110, 113; Jordan: 86; Laos: 88, 90; Lebanon: 82; Libya: 78, 86; Lithuania: 90; Mariana Islands: 81; Marshall Islands: 84; Mongolia: 100; Morocco: 75, 79, 84, 84, 84; Netherlands: 101, 107; Nepal: 78; New Caledonia: 85; Norway: 100; Pakistan: 86; Papua New Guinea: 82; Philippines: 86, 94; Poland: 90, 106; Portugal: 101; Romania: 88; Russia: 96, 97; Saudi Arabia: 78; Serbia: 88, 89; Slovakia: 96, 100; Slovenia: 96; Spain: 94, 97, 98; Sri Lanka: 79; Sweden 104; Switzerland: 101; Syria: 83; Thailand: 88; Turkey: 87; United Kingdom: 100; Vietnam: 94; Western Samoa: 86, 88, 90.

From Wicherts et al. (2010c, Table 1) (sub-Saharan Africa) — Central African Republic: 71; Congo (Brazzaville): 77, 77; Democratic Republic of Congo (Zaire): 74, 83; Ethiopia: 68, 69; Madagascar: 82; Mali: 71, 76; Nigeria: 86; South Africa (blacks): 66, 74, 75, 78, 79, 82, 84, 90, 96; Zambia: 75, 75, 75, 79, 83, 84; Zimbabwe: 77.

Appendix C

Listed below are average IQ scores from Caribbean countries populated primarily by people of sub-Saharan African ancestry. These scores were added to the paper's main data set to help assess the impact of parasite prevalence on average IQ.

From Lynn and Vanhanen (2012) — Barbados: 80; Dominica 71; Jamaica: 71; St. Lucia: 62; St. Vincent: 71.

From www.humanvarieties.org (24 January 2013c and 1 March 2013a) — Haiti: 64, 98; Jamaica: 59, 64, 67, 68, 70, 74, 75, 79, 79, 81, 84, 85, 86, 88, 94.

Scores not used from Lynn and Vanhanen (2012) — Jamaica: 60, 67.

Jamaican test scores not used from www.humanvarieties.org, though obtained from reasonably representative samples — 58, 88, 96.

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