IQ and National Productivity

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Abstract: A recent line of research in economics and psychology hypothesizes that differences in national average intelligence, proxied by IQ tests, are important drivers of national economic outcomes. Cross-country regressions, while showing a robust IQ-growth relationship, cannot fully test this hypothesis. Thus, recent work explores the micro-foundations of the IQ-productivity relationship. The well-identified psychological relationship between IQ and patience implies higher savings rates and higher folk theorem-driven institutional quality in high average IQ countries. Experiments indicate that intelligence predicts greater pro-social behavior in public goods and prisoner's dilemma games, supporting the hypothesis that high national average IQ causes higher institutional quality. High average IQ countries also have higher savings intensity by a variety of measures. Other possible IQ-productivity channels are discussed, as are possible environmental causes of differences in national average IQ.

In recent years, some economists and psychologists have proposed that the average level of intelligence in a country—measured by conventional IQ tests—is an important independent driver of economic outcomes. As psychologists have known for decades, average IQ scores differ when given to large samples in different nations, and recent estimates indicate national average IQ correlates 0.7 with log GDP per capita (Figure 1).

The macroeconomic question of interest is why IQ, which has a modest relationship with individual wages within a country, has such a strong relationship with average worker productivity across countries. When IQ is normalized in conventional IQ points (UK mean =100, standard deviation = 15), one IQ point is associated with approximately 1% higher wages, but 6 to 7% higher national productivity. While higher national productivity almost certainly raises IQ for the poorest countries, this reverse causation may not be the whole story, and indeed channels running from income to IQ have been widely studied already (Jones and Schneider 2006, 2010, and citations therein.). This essay focuses instead on potential cognitive spillovers, channels through which national IQ could have payoffs to nations that only indirectly reward high IQ individuals. These possible channels include better-informed voters, more cooperative workers and political elites, more saving (in a world of capital frictions) and access to higher-quality production functions (in a world of complementarities to worker quality).

A brief summary of IQ testing and of the possible drivers of national IQ differences is provided below; the discussion includes possible methods of raising national average IQ.

The essay proceeds as follows. Section 1 summarizes modern psychometric estimates of intelligence and the major databases of national average IQ. Section 2 discusses the labor literature on IQ and wages; section 3 discusses growth regressions that control for national IQ. Section 4 discusses two channels—patience and skill complementarities--by which intelligence might influence national GDP per capita; and section 5 turns to institutional channels. Section 6 discusses methods that could raise national average IQ, including environmental, nutritional, and health interventions, educational interventions, and immigration policies; section 7 points to areas for future work and concludes.

1. Measuring intelligence

What is intelligence? Can it be measured? The answers to the first question range from "intelligence is what intelligence tests test" (Peak and Boring, 1926, p. 71) to the more useful statement that intelligence is a model of mental ability built around "the empirical fact that all mental abilities are positively correlated" (Jensen, 1998, p. 45). In other words, people who are better at mathematical reasoning tend to do better than average on trivia tests, people who are worse than average at pattern-finding tend to be worse than average at vocabulary tests or memorizing long lists of numbers. The precise value of the correlation across mental tasks varies across tasks but it in large, diverse samples it is non-negative.[i]

Psychologists have found this positive correlation so often that in academic research, intelligence is often operationalized as the "*g* factor," the first principal component from a large battery of mental tests (Jensen, 1998, c.3). This one summary statistic, *g*, is often translated into units known as an IQ score. IQ is normed at a mean value of 100 within the UK, and the standard deviation of IQ within the UK is defined as equal to 15 IQ points. In practice, and within this essay, other types of IQ tests that use other metrics are converted into the IQ scale with UK mean 100 and standard deviation of 15.

A vast literature across the social sciences has documented the many conditional and unconditional correlates of IQ: within affluent countries, individual IQ scores correlate positively with lifespan, wages, and (*sic*) myopia; it correlates negatively with criminality, tendency to smoke, and number of motor vehicle accidents (Jensen, 1999, c. 9). These correlates are well-known. Some less-well-known correlates of individual IQ include *in vivo* brain size measured with MRIs and CT scans (typically +0.3 to +0.4, cf. Wickett et al. 2000), nerve conduction velocity between the eye and the vision centers of the brain (+0.4), and reaction time and inspection times (respectively, speed with which one presses a lighted button and the minimum amount of time one needs to decipher whether a quickly-flashed symbol was, say, an "I" or an "L")(Jensen, 1999, c. 6, Deary, 2001). These newer correlates of IQ are much less subject to the criticism that people with high IQs are just people who test well. Instead, they are something more: They are quicker.

Can IQ be measured across countries, even in developing countries? And if so, do these tests have similar real-world reliability to IQ tests given within OECD countries?

The answer to both questions is yes, with some modest grounds for caution. IQ tests have been translated into dozens of languages, and private companies who sell IQ tests to schools, hospitals, and firms have often created nation-level standardization samples of 1000 or more. Although non-psychologists often think of IQ tests as "pencil and paper tests," in fact the widely-used Wechsler IQ tests involve mostly talking with a psychologist and answering her verbal questions; a few subtests involving solving wood block puzzles, assessing pictures, or (occasionally) writing some answers with pencil and paper.

Further, IQ tests exist that are entirely non-verbal: the Catell Culture-Fair test, the Raven's Progressive Matrices, and the Draw-a-Man test are three prominent examples. So any researcher who chose to estimate a nation's average IQ score would have a wide variety of tests from which to draw.

The psychologist Richard Lynn and the political scientist Tatu Vanhanen (henceforth LV) assembled two collections of IQ scores by scouring the academic and practitioner literatures for reported IQ in a total of 113 countries (2002, 2006). They included some IQ standardization samples and some national tests of math ability, but most of the studies they used were "opportunity samples," studies of an ostensibly typical classroom or school in a particular country. As Jones and Schneider (2010) show, the high-quality samples and opportunity samples are highly correlated, and have a mean absolute deviation of 3.2 IQ points.

Recall that the LV IQ estimates correlate 0.7 with log GDP per capita. Because the LV sample includes many types of IQ tests and because LV describe the IQ tests that make up each nation's IQ estimate, Jones and Schneider (2010) were able to show that this correlation holds if one uses only IQ estimates from nonverbal IQ tests. The correlation between Ravens IQ and log GDP per capita is between 0.9 and 0.7, depending on the form of the test; the Ravens was the only single test used often enough to calculate test-specific correlations. And regardless of the type of IQ test used, rank order across countries is little-affected.

LV used these data to create estimates of national average IQ; theirs were the first databases of national average IQ, but not the last. When LV had multiple plausibly representative IQ estimates for a country, they took the mean (2002) or the (likely superior) median (2006) from across the studies. In their 2006 dataset, they have data from 113 countries, and for most countries they have more than one study to draw upon. The global mean IQ (unweighted by population) is 90, 2/3 of a UK standard deviation below the mean, and the standard deviation across countries is 11 IQ points. In recent work, Rindermann and coauthor (2007a,b; 2011) and Lynn and Meisenberg (2010a) have created new average national IQ estimates using more rigorous methods but for fewer countries; since their estimates correlate strongly with the larger LV 2006 sample, I largely use the latter in this essay.

One question is whether these IQ measures across countries are reliable, whether they measure differences in the same battery of mental skills across countries as they do within countries. On a variety of measures, one can say that the answer is yes. Leaving aside the purely psychometric measures of cross-cultural IQ validity (a longstanding research area in psychology, see citations in Jensen, 1998, c. 11), economists have found that within low average IQ countries, IQ scores have approximately the same relationship with wages as they do in rich countries. In both rich and poor countries, 1 IQ point is associated with between 0.5% and 1.25% higher wages. One study in rural Pakistan using the Ravens IQ test (Alderman et al., 1996) found that 1 IQ point was associated with 0.9% higher wages, very close to the Zax and Rees (2002) estimate of males in Wisconsin; and other examples can be multiplied (Behrman et al. 2004).

Some social scientists have criticized the LV datasets (Volken 2003, Wicherts et al. 2010a and citations therein); early criticisms included claims of one- to two-point errors in recording or interpreting the underlying data. In only one case was a misinterpretation substantial (Equatorial Guinea, mistakenly given an IQ estimate of 59; Lynn has dropped this observation from his most recent update). Random errors in the one- to two-point range are regrettable but almost surely irrelevant for empirical work; and to the extent that they introduce errors in variables, they will understate the true relationship in bivariate regressions (Durbin, 1954).

More recent criticisms arose in a series of papers by Wichters et al. (2009, 2010a,b) focusing solely on LV's sub-Saharan African IQ estimates. These critics note that LV exclude many studies of African IQ from their sample, and include some studies where the researchers reported health problems or enormous irregularities in test administration (for instance, some children taking a test in rural Africa were inexperienced in the use of pencils). Lynn and Meisenberg's response (2010b) responded to this critique in part by noting that tests preferred by Wicherts sometimes included college-students samples or otherwise elite populations, samples likely to be unrepresentative in undeveloped countries; indeed, LV always omitted college-only samples when estimating IQ for rich countries, so their treatment was symmetric across rich and poor. This exchange is highly recommended for insight into how databases are constructed; and Young (2010) is recommended as a parallel reminder of the weaknesses of African GDP data.

On the question of student health, if poor health hurts both measured IQ and the underlying skill the IQ test is designed to measure, then researchers should *hope* that such samples of students are included in a national IQ estimate: While there is certainly real interest in knowing what a nation's average IQ would be if all students had first-world health and nutrition, it is also of great interest to know how student's brains are performing in the world as it currently exists.

In a surprise ending to the dispute between Lynn and Wicherts et al., the latter chose (2010b) to look at individual studies that used only large, nationally representative samples, samples that met all of their quality requirements. In their K-12 samples, the median IQ across a variety of sub-Saharan African countries was 76.5—about half an intra-UK standard deviation away from Lynn's own estimate of average sub-Saharan African IQ: 70. By either measure, sub-Saharan African nations currently have the lowest average IQs of any region of the world. As Wicherts et al. themselves conclude, "[t]here can be little doubt that Africans average lower IQs than do Westerners" (Wicherts et al., 2010a, p. 17).[ii]

Thus, the academic critics and Lynn agree on the point that is of most interest to economists: IQs differ across countries, and the rank order of the difference has broad agreement. As we shall see below, in applied cross-country work researchers have both Winsorized the data to 80 or 90 or included sub-Saharan African dummies, partly to take account of the possibility that these scores are inaccurately low. Researchers have taken the Wicherts et al. critiques into account.

2. IQ and Wages

A routine finding in labor economics is that childhood and adolescent IQ scores in developed countries are positively correlated with adult wages (Bowles et al. 2001, Neal and Johnson 1996, and citations therein). This holds whether or not one controls for education. In a conventional diminishing returns, price-taking setting, the relationship between IQ and wages is the relationship between IQ and the marginal product of labor. Jones and Schneider (2010) use this fact to estimate the microeconomic effect of differences in national IQ on national productivity.

Using their preferred estimate for ease of exposition, 1 IQ point is assumed to cause 1% higher micro-level productivity.

Based on Ramsey and Solow model intuitions, economists might expect that at the national level in steady-state, this would cause an even greater effect on macro-level productivity: IQ raises the marginal product of labor, and since in a Cobb-Douglas production function this is observationally equivalent to an increase in TFP, this would raise the marginal product of capital as well. In steady state, one would expect this to increase the level of capital in order to reduce the marginal product of capital back to its steady state level. All of these channels are correct, but nevertheless conventional theory predicts that for conventional production functions, the micro level IQ-productivity relationship is identical to the macro steady-state IQ-productivity relationship.

The micro and steady-state macro effects are identical because the micro relationship among human capital, wages, and productivity already assumes that capital is drawn to highly productive labor. Consider the case of two types of workers with IQ levels IQ_L and IQ_H, $IQ_H > IQ_L$. The size of each group of workers is normalized to unity. The workers share a fixed homogenous capital stock $K_L + K_H = K$ and use production function

$$Y = K_L^{1/3} IQ_L^{2/3} + K_H^{1/3} IQ_H^{2/3}.$$

If capital can flow freely and the representative firm is a price-taker, then capital will flow toward the high IQ workers until the marginal product of capital is equalized across the two categories of workers. In equilibrium, workers with 10% higher IQ will have 10% more capital, because they provide 10% more effective labor. One can place quotation marks in the previous sentence around either “more effective” or “effective labor”: the management science interpretation is different, but the implications for the capital-labor ratio are the same. Thus, micro-level cross-section wage regressions include the endogenous effect of physical capital's attraction to workers with higher levels of human capital.

One can use the cross-sectional relationship between IQ and wages within a country to test the validity of the LV IQ measures. In an ideal test, one would want to randomly select workers from different countries and place them into a new country, wait a few years, and then measure their wages. One could then determine whether the average immigrant from a country with an LV IQ 10 points lower than her new country earns 10% less than the average person in the new country. This experiment would hold institutions, capital and many other features constant, and only vary the country of origin of the experimental subjects.

Such an experiment is impossible and undesirable in its pure form, but immigrants to the U.S. provide a useful approximation. Using Hendricks's (2002) data on wages of immigrants to the U.S., Jones and Schneider (2010) regress the average income of immigrants from each country (whether or not adjusted for education) on that nation's LV IQ. They find approximately the same 1:1 IQ/wage relationship others find in the labor literature: immigrants from higher LV IQ nations earn modestly more after arrival in the U.S. than immigrants from lower LV IQ nations. A one-point increase in national average IQ predicts an approximate 1% increase in average income of immigrants from that country. In a simple calibration Jones and Schneider find that this private marginal product of labor channel can explain approximately 1/6th of the cross-country variation in log productivity per worker. Workers from higher LV IQ countries are typically more productive, although this private productivity channel is likely far from the whole story.

3. National IQ in Growth Regressions

Growth regressions also support the hypothesis that higher LV IQ causes better economic performance. LV themselves ran bivariate correlations and one- and two-variable growth and level regressions, always finding a strong relationship between national average IQ and the outcome of interest. Weede and Kampf (2002) ran more conventional Mankiw-Romer-Weil/Barro-style cross-section growth regressions, controlling for institutional quality, schooling, and starting GDP per capita; again, national IQ was a reliable growth predictor. While some regressions had been reported, the question of LV IQ's overall robustness was unclear.

Jones and Schneider (2006, henceforth J/S) answered the question of LV IQ's robustness by including (*inter alia*) 455 cross section growth regressions using the dataset and combinations of the control variables from Sala-i-Martin, Doppelhofer, and Miller (2004, henceforth SDM). J/S only included the 18 growth regressors that were robust in SDM's Bayesian Averaging of Classical Estimates exercise. They included geographic dummies, years open to trade, and ethnolinguistic fractionalization among other controls. Their regressions included three fixed controls (the 3 most robust SDM regressors: log GDP per capita in 1960, primary schooling in 1960, and the price of investment goods) and all 455 possible permutations of the remaining 15 robust controls taken three at a time. Thus seven controls were included in every regression. National average IQ was statistically significant at the 1% level in *every* regression.

J/S provide additional Bayesian model averaging robustness tests that accord with this result. Ram (2007) also found that national IQ was a statistically significant growth regressor in multiple specifications. Using the structural equation methods common in psychology, Rindermann and Thompson (2011) have found a reliable positive relationship among national average cognitive skills, good pro-market institutions, and good economic performance. Notably, that paper includes a separate estimate of the cognitive skills of the highest-scoring 5% of the population in his OECD-heavy sample; they find that the skills of the top 5% have disproportionate predictive power for good outcomes.

J/S use their mean IQ growth regression coefficient to calculate the predicted steady-state relationship between LV IQ and GDP per capita. This calculation, derived from Jones (2000) and Barro and Sala-i-Martin (2001, p. 466ff.), is both practical and rarely used. Recall the conventional cross-sectional growth regression, where y_i is GDP per capita for country *i* at the beginning of the time period, $\Delta\ln(y_i)$ is the log change in GDP per capita over the sample period, β is the speed of convergence to steady state (typically found to be 2% per year (Barro and Sala-i-Martin 2001, p. 496, p. 521; for an early critique see Quah 1996)), X_i is a column vector of other controls, and θ' is the row vector of coefficients corresponding to those controls:

$$\Delta\ln(y_i) = \gamma - \beta\ln(y_i) + \theta' X_i + \varepsilon_i$$

If we assume that technology grows at an exogenous rate[iii] and appropriately demean the other variables, then γ is the steady-state growth rate of GDP per capita, conventionally considered 2% per year over the past century. Under the Solow-style assumption of conditional convergence, all steady-state growth in per capita GDP is caused by γ: So any growth seen over the sample period greater or less than γ is caused by convergence to a nation's steady state path of GDP per capita. This suggests the following transformation:

$$\Delta\ln(y_i) = \gamma + \beta[\lambda' X_i - \ln(y_i)] + \varepsilon_i$$

where $\lambda = \theta / \beta$. By factoring out a β from the coefficient on the so-called growth regressors, we see that under the assumption of conditional convergence "growth regressors" are actually steady-state log-level regressors. Therefore the coefficients θ on these growth regressors are actually coefficients for the steady-state log-level effect λ multiplied by the rate of convergence, β. The term in square brackets has a straightforward interpretation: It is the gap between starting log GDP per capita and steady-state log GDP per capita.[iv] The gap between the two closes at rate β per year.

Jones and Schneider find that 1 IQ point is associated with slightly more than 0.1% faster annual GDP growth; given their β estimate of slightly less than 2, they estimate that 1 IQ point predicts 6% higher steady-state GDP per capita. As noted already, this is at least six times greater than most estimates of the micro-level relationship between IQ and individual productivity, and it is consistent with the hypothesis that IQ has positive spillovers. The next two sections discuss what some of those cognitive spillovers might be.

4. Skill complementarities and patience

This section considers two channels for IQ spillovers: Complementarities to worker skill and the well-identified link between patience and intelligence.

Kremer (1993) notes that much of modern production is fragile: He discusses the explosion of the space shuttle Challenger, destroyed by the failure of a single O-ring, a band that sealed the burning rocket engine. Less tragically, more routinely, many production processes have such "weakest link" elements, where many workers toil on a project, and where failure at any one step of the production process can destroy the value of the whole. As Kremer notes, clothing with minor flaws is sold a steep discounts and computer chips with the smallest flaws are unusable.

In weakest link settings, Kremer shows that it is privately rational and socially efficient for workers to sort across firms by quality. To take the simplest example assume two types of workers of quality q_H and q_L, with effective labor of q_L=0.5q_H. The production process has two steps and output is mulitiplicative in worker quality: Y=q*q. This production function could represent, as Kremer notes, the process of making a vase, where any worker has some probability 1-q of dropping the vase (the probability of completing a particular vase is then q^2); or where an error at any step in the production process would reduce the value by some fraction q.

Given a fixed supply of workers and equal amounts of both types of workers, it is efficient to sort workers into firms where all workers are of the same quality:

$$q_H^2 + q_L^2 = 1.25q_H^2 > 2q_Hq_L=q_H^2.$$

Within a given firm that had both types of workers, the firm would voluntarily sort the workers to maximize output. Kremer shows that this result is generalizable to decentralized economies with physical capital stocks and large varieties of worker skill: If production functions have complementarities to skill, market forces will tend to sort workers into firms by skill level.

Kremer draws on this finding to help explain why rich countries tend to have higher levels of human capital: Higher average levels of worker skill open the door to using more advanced technologies (which may demand longer production chains), while nations with lower skill levels will be able to produce little output, since long production chains dramatically increase the probability of a value-destroying error.

The Kremer model thus provides a new reason for believing that returns to human capital may be large; but how could one reconcile the hypothesis that human capital returns are large across countries with the routine finding that returns to human capital are modest within countries? The model of Jones (2010) provides one resolution: the model proposes that there are two production technologies available in each country, a Kremer-style O-ring technology and a diminishing returns to scale, Cobb-Douglas "Foolproof" technology that works according to the conventional model of Part II.[v] In this Cobb-Douglas sector, workers of different skill levels can readily work together in the same production process, and average skill level is a sufficient index of worker quality. In the Foolproof sector, workers that are 1% lower in average quality might early only 1% less; whereas in the O-ring sector, 1% average lower worker quality causes a much larger decline in output and hence wages.

Consider the case of two types of workers, again q_H and q_L: High-skilled workers voluntarily sort between the two sectors until wages for q_H workers equalize. The model's key result is that as long as there are not too many lower-skilled workers, the q_L workers will voluntarily sort into the Cobb-Douglas sector, producing slightly less output and earning only slightly lower wages than other, higher skilled workers in the same country. The q_L workers would not want to use the O-ring technology since they are much less productive with that technology; lower quality workers are poor substitutes in the O-ring sector but good substitutes in the Foolproof sector.

But a nation of q_L workers would produce little with the O-ring production technology; they would likely crowd into the Cobb-Douglas sector, producing little indeed though still more than if they used the O-ring technology. The Foolproof sector is appealing to low-skilled workers when there are few people in it; because it faces diminishing returns (or limited demand for Foolproof goods and services), a nation of q_L workers in the Foolproof sector will have very low average productivity. Returns to human capital will be small within countries but large across countries. The model is thus consistent with the empirical observation that IQ has a strong relationship with cross-country productivity but a weaker relationship with intra-country productivity.

While the O-ring/Foolproof model matches this fact, further work can investigate whether other implications of the theory hold true: Do low-skilled and low-IQ workers take on more complex, delicate tasks when living in nations with low average IQ? Do high-skilled, high-IQ workers take on more mundane tasks when working in high-average IQ countries? Within a country, are new technologies massively more productive when used solely by higher-IQ workers? Production functions, so widely used in economics, are still undertested in empirical work.

Another link between IQ and national productivity is driven by IQ's reliable correlation with patience. In intertemporal optimizing models of national economies, the rate of time preference is always a key parameter, one that influences long-run interest rates, investment, and the capital stock. Growth economists typically assume the rate of time preference is identical across countries. Is this assumption tenable? Psychological research and behavioral economics research combined with LV IQ estimates suggest the answer is no. And recently, Banerjee and Duflo (2011) have written that reduced willingness to delay gratification may be of first-order importance in explaining global poverty: "the poor…often behave as if they think that any change that is significant enough to be worth sacrificing for will simply take too long. This could explain why they focus on the here and now…"

Psychologists have known for decades that patience and IQ are almost always positively correlated. Shamosh and Gray (2008) survey this literature finding that in 23 out of 26 experimental studies, high IQ individuals are more likely to delay gratification.

Shamosh and Gray suggest one channel through which intelligence could directly cause patience: Through the ability to keep multiple facts simultaneously in one's mind. One strong correlate of overall intelligence—indeed, one subtest of some IQ tests—is memory span: The quantity of numbers or letters that can a person can recall a few moments after hearing them. Since considering the opportunity cost of consuming now versus later requires keeping four hypothetical situations in mind (consuming vs. not consuming now; not consuming vs. consuming later), memory span provides one cognitive foundation for the IQ-patience relationship. Further work can investigate other possible channels.

In one well-known study of delayed gratification Mischel et al. (1972), the experimenter gave a 4 to 6 year old child a marshmallow, and then told the child that he was going to leave the room. He told the child that if she waited until he returned to eat the marshmallow, the child would get a second marshmallow. The experimenter then waited long enough that almost all children eventually ate the marshmallow (or other treat); minutes until marshmallow was then recorded as the key experimental outcome.

Children used many innovative methods to avoid thinking about the marshmallow on the table in front of them such as "covering their eyes with their hands or talking to themselves" so they would think less about the marshmallow (p. 205). These innovations are suggestive of a link between delayed gratification and intelligence. And the evidence supports such a suggestion: In a 1990 follow-up of the adolescent behavior of these same test subjects, Shoda et al. found that children who waited longer before eating the marshmallow had higher SAT verbal ($\rho=0.42$, $p<0.05$), and SAT quantitative ($\rho=0.57$, $p<0.001$) scores.

Since children's differences in waiting time are measured in mere *minutes*, then any attempt to convert this study's results into a parameter linking SAT (and its strong correlate, IQ, cf. *inter alia* Frey and Detterman (2004), Beaujean et al. (2006)) to the *annual* rate of time preference would involve astronomical numbers. With half a million minutes per year, any IQ-delay finding from such an experiment extrapolated to the annual β or ρ parameters familiar from growth economics would predict that low-average-IQ countries would have negligible savings. In the original study, Mischel et al. found that older children waited longer; this suggests that this is not an age-invariant parameter. While the IQ-patience relationship is well-documented, economists will have to search further for a parameter relevant for national economies.

Two recent studies by economists have provided evidence that among adults, the IQ-patience relationship *can* be mapped into the familiar space of choices over long time periods. Dohmen et al. (2010) using a sample of German adults find that in both hypothetical and actual choices of money now versus a year from now, a one intra-US standard deviation increase in cognitive skill is associated with a decline in the discount factor. Further evidence comes from the U.S. peace dividend of the early 1990's: when the U.S. military downsized, it offered enlisted personnel who wanted to separate early the option of an immediate lump-sum payment or an attractive annuity with an internal rate of return greater than 17%. Even controlling for income, years served, age, education, and many other factors, scores on an enlisted person's Armed Forces Qualifying Test was a statistically significant, correctly-signed predictor of one's likelihood of accepting the attractive annuity (Warner and Pleeter 2001).

Jones and Podemska (2010) convert these estimates of the relationship between cognitive skill and time preference into a parameter, $d\rho/d(IQ)$. Their benchmark estimate is that one IQ point lowers the discount rate by 5 basis points. They then use that data in a conventional Ramsey growth model. In a closed economy, differences in national IQ would predict less investment and hence lower steady-state capital-output ratios; Jones and Podemska show that indeed high IQ countries tend to have higher capital-output ratios and higher rates of savings.[vi]

This is an IQ externality because the capital stock with which one works and from which one earns interest is determined by the average IQ of one's national compatriots; if one were permitted to move to a higher-IQ country, one would be able to work with a larger capital stock through no effort of one's own. The missing market here is the market for global labor (or equivalently, frictionless global capital flows).

In an economy fully open to capital flows, Barro and Sala-i-Martin (2001, p. 164-165) describe the quite extreme steady state. In a purely theoretical discussion, they rank countries by order of time preference, denoting Country 1 as the most patient. Their theoretical result is stark:

> "Asymptotically, Country 1 owns all the wealth…[all] claims on capital and the present value of the wage income in all countries…All other countries own a negligible amount (per unit of effective labor) in the long run."

The reason for their result? Because the market interest rate—identical around the world--will eventually be set by the most patient country, and less-patient nations will voluntarily borrow money at that interest rate to consume more than their income until they have promised their entire future income stream (minus an epsilon amount, under the Inada conditions) to repay the debt.

Because this conclusion is considered unrealistic, growth economists typically assume that there are frictions that keep any one nation from promising its entire future income stream as collateral. But as barriers to international finance have fallen in recent decades, then one might expect the world to move, if not entirely to the Barro/Sala-i-Martin steady state, at least in that direction.

Jones and Podemska (2010) claim that for many countries, holdings of U.S. Treasuries, a liquid form of wealth, are one indicator of whether a nation is building up its stock of global savings. Omitting a few offshore banking havens and OPEC countries, they find that high

LV IQ countries hold a disproportionate share of U.S. Treasuries as a share of their nation's GDP: High LV IQ countries have high Treasury/GDP ratios, a result that holds after controlling for GDP per capita.

The Treasury/GDP ratio is an imperfect index of global saving; they are gross measures, not net. If nations with high Treasury/GDP ratios also were massive net borrowers, the Jones and Podemska (2010) result could be completely overturned. Fortunately holdings of net foreign assets are also available, with annual data from 1970 to 2004 (Lane and Milesi-Ferretti, 2004, 2007). This ratio of net foreign assets to GDP has the same positive predicted relationship with LV IQ. Omitting the OPEC countries, the phosphorous-rich micronation of Kiribati, and Liberia, the world's most FDI-intense nation, the correlation between LV IQ and net foreign assets to GDP in 2005 was +0.4; including all of these outliers increases the estimated regression coefficient, since Liberia is a massive recipient of foreign capital, though the t-statistic on IQ falls to 5. The relationship has strengthened over the period as barriers to capital flows have fallen since the end of Bretton Woods; in 1970 the correlation was +0.2.

Thus, mainstream growth theory combined with a conventional result in psychology (IQ's link to patience) can partially explain why some nations hold more financial and physical capital than others: Nations with higher average intelligence are more patient, and the patient inherit more of the earth.

5. Institutional Channels

Caplan and Miller (2010) find that within the U.S., voters with higher IQs are more likely to support market-oriented policies, even controlling for income, education, and political orientation. This might come as little surprise to those of us who have taught economics: The invisible hand is hard for some students to see, whether it comes to the unintended consequences of price controls or the power of the law of comparative advantage. Spontaneous order, multipliers, the law of unintended consequences: On average, the same individuals who on an IQ test can spot what is unusual in a drawing of a room full of children (one of the kids is facing the wrong way) are the same individuals who can see how doubling the minimum wage is likely to hurt employment opportunities for the poor.

Since politicians tend to respond to the demands of citizens, whether wise or unwise, nations (especially democracies) with higher LV IQ are more likely to support the market liberalizing policies that have been routinely found to be growth-promoting. And if individuals have a modest tendency to conform to their neighbor's views, the conventional finding of sociology, then the Caplan and Miller channel will become even stronger: People in slightly higher-IQ countries will have slightly higher-IQ neighbors, and tend to reinforce each other's slightly more liberal economic policy views. The urge to conform will create an IQ-voter quality multiplier.

O'Rourke and Sinnott (2006) provide preliminary cross-country evidence for the Caplan and Miller view: in the majority of countries, high-skilled workers are more supportive of trade than low-skilled workers. In the poorest countries, this relationship weakens, and it may reverse for countries at the GDP per capita level of the Philippines or below—nations with productivity 1/10th or less of frontier nations. Future research should investigate whether cognitive skills are good predictors of policy views in less developed countries.

Based on Caplan and Miller's results, one would predict that across the range of actually existing variation, high-IQ countries would tend to rank as freer on most indices of economic freedom. Unsurprisingly, this is the case: the Freedom House economic freedom measure correlates 0.6 with LV IQ (LV 2006, p. 251), and as we will see below national IQ also correlates positively with institutional quality.

Finally, smarter groups are more cooperative, more trusting, and more trustworthy in laboratory experiments (Pinker, 2011, p. 611). If wealth-promoting political institutions depend partly on tacit cooperation among political elites, then this channel may help explain why high LV IQ nations are so much more prosperous. Jones (2008) was the first to find that high IQ groups were more cooperative in repeated prisoner's dilemmas: he collected data on repeated prisoner's dilemma experiments run at dozens of universities and found that when such experiments were run at high-SAT universities, students cooperated more often. This result held after controlling for whether the school was private or public, and a variety of experimental protocols such as number of rounds and whether students played for real money.

Later work has reinforced this result: Burks et al. (2009) in an experiment run on students in a truck driving school, found that in a one-round, two-move sequential prisoner's dilemma (similar to a Berg et al. (1995) trust game), high IQ players were more likely to cooperate in the first move, and were more likely to reciprocate cooperation in the second move. The first move corresponds to "trust" and the second to "trustworthiness;" high IQ individuals possessed more of both traits in their sample.

Further, Putterman et al. (2010) found that among students at Brown playing a repeated public goods game, high IQ players were more likely to contribute more in early rounds of the game, and contributed more overall.[vii] And returning to Caplan and Miller's voter-quality channel, Putterman et al. found that when a voting round was added to the middle of the game, high IQ voters were more likely to vote for the efficient constitutional rule for punishing free riders. That IQ predicted pro-social behavior at an Ivy League university reduces the likelihood that the results in other studies are driven by extreme social deprivation of low IQ individuals, anti-cooperation cultural norms among the families of low IQ individuals, or other similar sociological and environmental stories: Among some of the world's most elite students, differences in IQ predicted differences in pro-social behavior.

One unconventional measure (Jones and Nye, 2011) finds that national average IQ and education levels are good predictors of law-abiding behavior in a nearly lawless setting: the world of diplomatic parking in New York City. Until 2003, United Nations diplomats in New York were not required to pay parking tickets. Fisman and Miguel (2007) assembled this unpaid parking ticket data by country and found that diplomats from high-corruption countries were far more likely to earn parking tickets: Corruption travelled with the diplomat. But Jones and Nye find that when controlling for the national average IQ of the home country, the home country education level, or both, the statistical significance of home-country corruption is reduced or eliminated. The corruption channel may be operating through a human capital channel.

These results matter for political institutions because politics is a repeated game where politicians are tempted to sacrifice long-run benefits for short-run benefits: high-level officials are tempted to take bribes that destroy transparency rather than reap the rewards of better institutions; judges and lawyers are tempted to collude rather than neutrally abide by the rule of law; members of parliament are tempted to confiscate capital after it has been invested in their nation (Jones 2011).

Repeated games abound in the public choice and political economy literatures, and in such models, a key parameter is always the discount factor, β. The discount factor is central to the folk theorem of repeated games: When players are more patient, players better able to reach the Pareto-efficient solution. And as we have seen already, high IQ individuals and groups appear to be more patient by a variety of measures. In a nation of patient players, politicians care more about long-run reputations (Persson and Tabellini 2000, c. 4), central banks find it easier to solve the time consistency problem (Barro and Gordon, 1983) and thereby sustain a low-inflation equilibrium, and officials engaged in Rubenstein bargaining problems will split rents more equally, likely reducing social conflict.

Potrafke (forthcoming) finds cross-country evidence that national IQ is a reliable predictor of low national corruption as measured by the Corruption Perceptions Index, even when including a variety of historical and policy controls (Figure 2). Surplus-destroying rent-seeking appears less common in high LV IQ countries.

If the links between IQ, patience, and pro-social behavior remain as strong as they appear in recent research, then differences in LV IQ are likely causing differences in the quality of institutions across countries. The political externalities of IQ may be large.

6. Maximizing Intelligence

What can be done to raise a nation's average level of intelligence? The public health literature has a set of obvious and data-driven answers: Environmental improvements, childhood nutrition improvements, and better prenatal care all appear to be ways to increase IQ. A vast literature on the topic is summarized in Armor (2003); a few key pieces of evidence will need to suffice for the purposes of this essay. The link between environmental lead and intelligence is well-established; one recent paper, Ferrie, Rolf and Troesken (2011) found that among World War II draftees in the US, higher exposure to lead through lead water pipes caused an IQ drop of 5 points. And in the Philippines, Solon et al. (2008) found that a 1 microgram increase in lead per liter of blood was associated with a 2.5 to 3.3 IQ point decrease in children. In the Filipino sample, children averaged 7.1 micrograms of lead per liter, a level that, extrapolated linearly, would predict at least a 15 IQ point decrease.

Until 2006, almost every sub-Saharan African country used leaded gasoline (United Nations 2002, 2008). The end of leaded gasoline in Africa will likely increase measured IQ in coming decades.

Experimental studies in developed and less-developed countries both suggest that for some individuals, IQ can be increased by providing proper micronutrients (Armor 2003, Jensen, 325-326). Nutritional channels are likely important in developing countries: in Pune City, India, a mere 10 weeks of zinc supplementation caused a 15-25 percent increase in student scores on the Ravens (Tupe and Chiplonkar, 2009). Notably, zinc supplementation increased the speed with which students pressed lighted buttons: Reaction time improved. Berhman et al. (2004) also survey evidence that increases in maternal and child health will increase IQ: Iron and iodine deficiencies appear to be barriers to riches in the poorest nations.

A finding of the greatest importance is the Flynn Effect (1987), the well-known and conclusively documented trend of rising IQ across the rich countries. At least until the last decade, it appears that IQ scores have risen by 2 to 3 points per decade across at least the second half of the 20th century in the developed countries; while the debate continues over how much of this is nominal versus real (e.g., test-taking skill versus real-world problem solving and memory skill), there are sound reasons for believing that some portion is a genuine increase in mental ability.[viii] If this is so, then economists should bring their unique tools to bear on the important question of why IQ has risen in the rich countries. Perhaps they will find ways to spur and strengthen a Flynn effect in the world's poorest countries. The most comprehensive discussion of the Flynn Effect is contained in a volume edited by Neisser (1998).

Finally, Eppig et al. (2010) have used the LV national average IQ data to argue that parasite prevalence, which correlates negatively with LV IQ, in fact helps to cause low national average intelligence.

If IQ provides some of the long-run positive externalities discussed in this essay—raising voter quality, improving institutions, providing access to frontier technologies, and raising capital intensity—then the benefits to improving public health are greater than currently believed.

Education may also increase overall intelligence; here the evidence is more scattered, but at the very least it appears plausible that increases in the quality and quantity of education raise measured IQ. Winship and Korenman (1997) drawing on the NLSY and comparing their results to other studies, conclude that one extra year of ostensibly exogenous education increased IQ by "somewhere between 2 and 4 points" (p. 218). Hansen et al. (2004) used nonexperimental methods to come to a similar conclusion. Card and Rothstein (2007) used plausibly exogenous variation in residency driven by desegregation court orders in the U.S. as in instrument for exogenous quality of schooling and peers. They found that an end to racial segregation in schools closes "about one-quarter of the raw black-white gap in SAT scores," an IQ proxy (p. 2158).

The question remains whether these increases are what Jensen calls "hollow IQ," mere test-taking skill rather than an increase in intelligence: Perhaps future work can investigate whether the pattern of nerve conduction velocity and response times also moves in the expected direction when students exogenously receive increases in the quality and quantity of education.

One can also increase national average IQ quite reliably by allowing high IQ individuals to immigrate. A decision to admit high IQ immigrants as voting citizens would yield both the neoclassical and the institutional benefits of higher national average IQ. And since IQ correlates positively across generations, if high IQ immigrants raise families in their destination country, then they will likely provide long-lasting benefits to the country that admits them.

If IQ has the sizeable positive externalities posited here, then there may be room for a Coasian bargain between countries with low current LV IQ and higher IQ individuals in other countries. One purely suggestive possibility: If the ratio of private to public benefits of higher IQ are even half as large as the 6:1 ratio suggested by Jones and Schneider (2010), a low LV IQ country could rationally offer a 100% subsidy for any wages a high IQ immigrant earns in excess of that nation's median wage. In practical terms, a 10 year income tax holiday for permanent immigrants with engineering degrees could accomplish the same goal of encouraging high IQ immigration.

A closing word on the question of possible genetically-driven differences in national average IQ. In developed countries, at the within-country, within-ethnicity level, it is clear that a substantial fraction of variations in IQ are genetically driven—around half or more (Caplan 2011, Boomsma et al. 2008, Plomin et al. 2000, Devlin et al. 1997). But the tools that behavioral geneticists use to establish the heritability of IQ or features such as height, eye color or personality—twin studies and adoption studies—are rarely applicable for studying ethnic differences in intelligence, and of little use in studying cross-country differences.

Recent psychology textbooks and surveys (Loehlin 2000, Hunt 2011, Mackintosh 2011) discuss the issue of ethnic differences in intelligence, partly drawing on adoption studies of children of East Asian and African descent adopted by families of European descent; here I discuss only the East Asian data.[ix] One study cited by Loehlin and Mackintosh notes that adoptees of East Asian descent performed better than average on IQ tests; another repeated finding noted by these authors is that Native Americans, closely genetically related to East Asians, have a similar pattern of relatively high visual-spatial intelligence compared to whites. Together with other pieces of evidence, these findings induced both authors to either tentatively accept (Loehlin) or at least consider plausible (Mackintosh) the hypothesis that the higher average IQ of East Asians is at least partly genetic in origin. The hypothesis that at least some portion of cross-country IQ differences is genetic in origin has mainstream support from within the psychology profession.

But genetic differences do not imply intractable differences. The myopia common among high IQ individuals is partly genetic in origin, yet eyeglasses and laser surgery have turned this genetic difference into a nuisance or less in wealthy countries. If IQ provides some of the long-run positive externalities discussed in this essay—raising voter quality, improving institutions, providing access to frontier technologies, and raising capital intensity—then the benefits to finding medical solutions for differences in IQ—whatever their origin--are greater than currently believed.

7. Conclusion

Since at least the work of Hanushek and Kimko (2000), economists have known that years of schooling are a poor measure of human capital; these authors found that national average test score measures were far better predictors of long-run economic performance. One weakness of the test score literature is that standardized math, science, and language scores are available for only a few dozen countries; another weakness is that little is known about non-school, non-wage individual-level correlates of such test scores (for expansions of these datasets, see Hanushek and Woessman 2007, 2010).

By using national average IQ as an index of human capital, growth economists can tap into a century of research by psychologists, sociologists, neuroscientists, geneticists, and microeconomists into the causes, correlates, and effects of IQ differences. Patience, pro-social behavior, and better-informed voting are among a few of the correlates of higher IQ discussed here, and others may exist. In cross-country growth regressions and calibrations, national IQ appears to have a much larger influence on economic outcomes than one would predict from conventional wage regressions; one can hope that future research will uncover practical methods for raising every nation's average level of cognitive skill.

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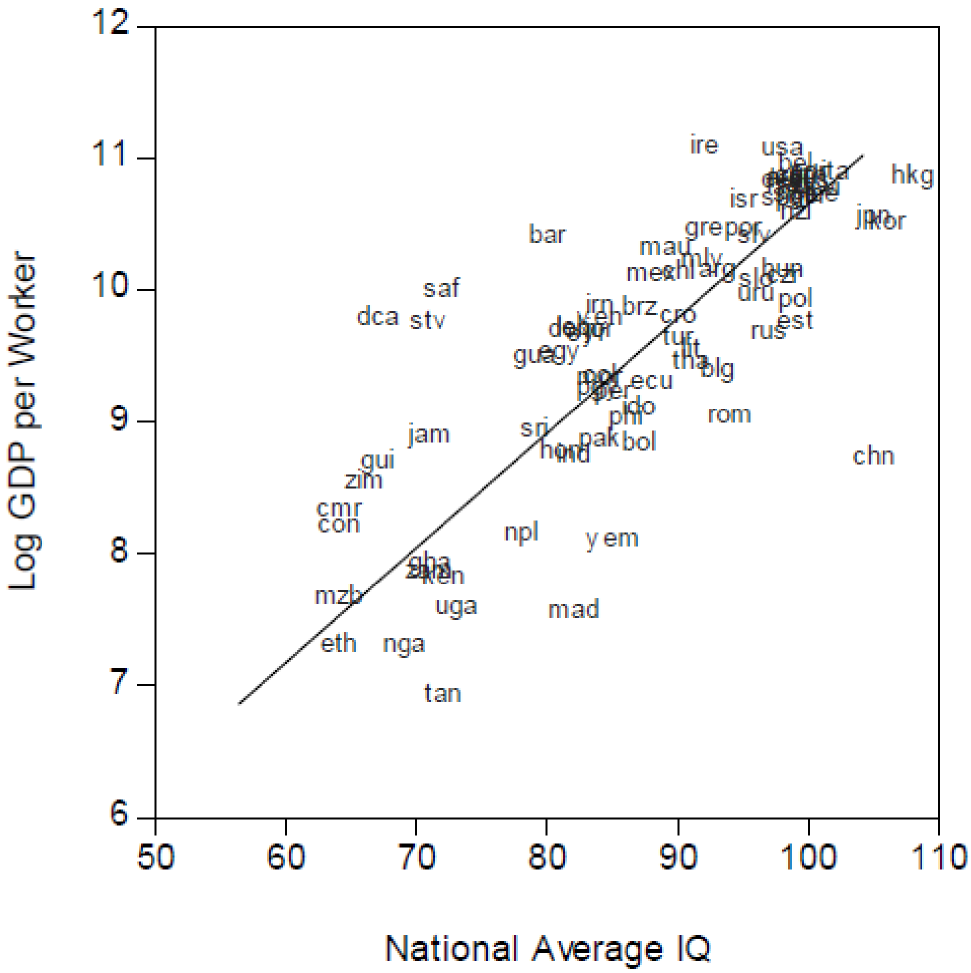
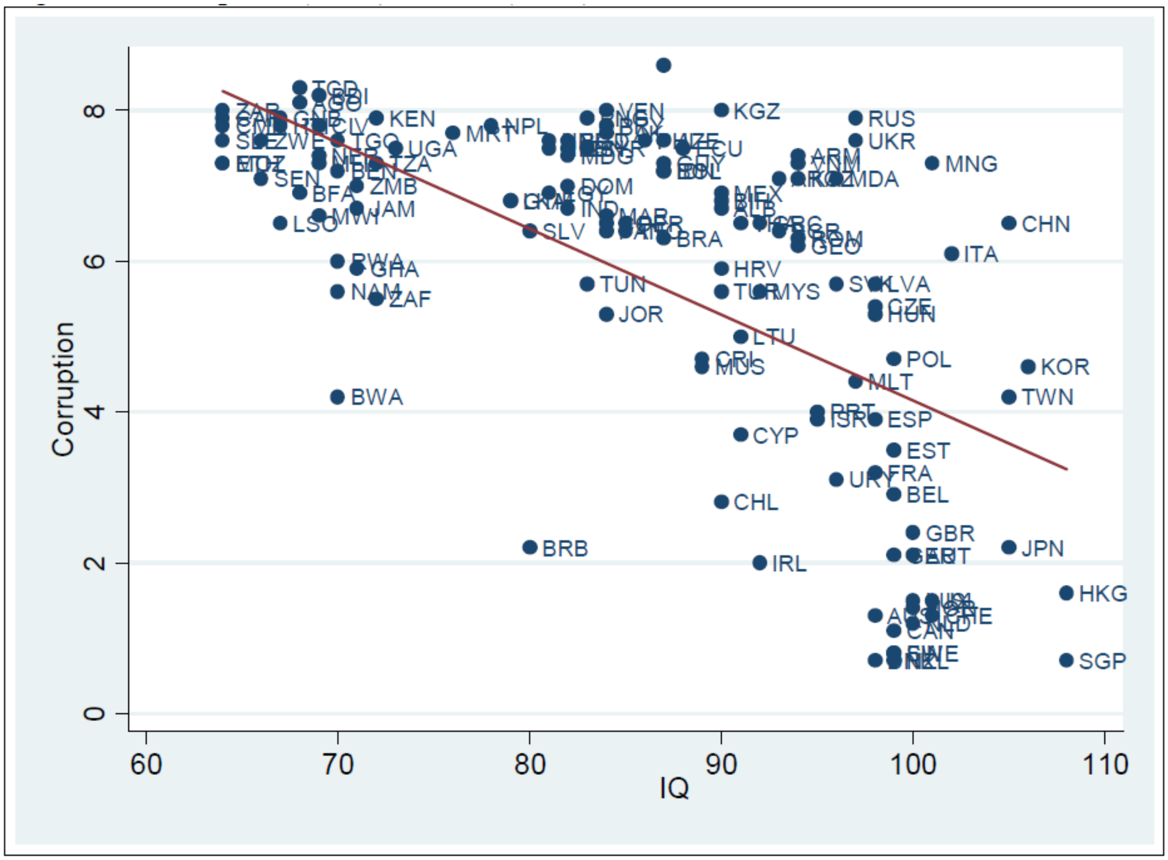
Figure 1
National Average IQ
and Year 2000 GDP Per Worker



Notes: Y-axis shows GDP per worker in logarithmic scale. The sample covers 87 countries. The outlier in the lower-right corner is China (IQ=105). High outliers, from left to right, are Dominica, St. Vincent, South Africa, and Barbados. Source: Lynn and Vanhanen (2006) and Penn World Tables 6.1 for IQ and GDP data, respectively.

Figure 2: National IQ and Corruption



Correlation coefficient: -0.63. Source: Transparency International (2010) and Lynn and Vanhanen (2006)

Source: Potrafke (forthcoming).

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[i] For a candid consensus document on the nature of intelligence authorized by the American Psychological Association, see Neisser et al., 1996. Note that if one looked only at individuals with identical IQs and different scores on IQ subtests, then within that group of individuals different mental skills would by definition be negatively correlated.

[ii] Wicherts et al. (2010a, p. 17) propose some methods of increasing average African IQ: "These include improvements in nutrition and health (care), increases [in] educational attainment, improvements in educational practices, urbanization, large-scale dissemination of visual–spatial toys, etc. Although it cannot be precluded that genetic effects play a role in the low IQ performance of Africans, we view environmental circumstances as potentially more relevant to the present-day difference in mean."

[iii] A conventional motivation for treating α as exogenous to a particular country is that the growth rate of useful technical knowledge is overwhelmingly external to any one country.

[iv] Strictly speaking, $\theta' X_i$ is log steady-state GDP per capita as of the end of the sample period: Given the exogenous growth rate, each nation's log steady-state GDP per capita increases by γ every period.

[v] The diminishing returns in the Foolproof sector reflects multiple ways in which non-O-ring technologies are less productive as they expand as a fraction of the economy: It can represent nontradable personal services, demand for which is limited; it could represent the use of well-understood production processes that were perhaps once O-ring in nature but are now relatively "Foolproof" (such as the production of aspirin); and it could represent traditional, nonscalable agricultural and manufacturing methods.

[vi] The empirical relationship between national IQ and savings, or national IQ and capital intensity, is quantitatively larger than one would expect from a simple Ramsey growth model when estimated in logs; it is close to the predicted relationship when estimated in levels. Peer effects on saving deserve attention as one possible reason for a stronger country-level relationship; Maurer and Meier (2008) find moderate peer effects on individual consumption spending using the Panel Study of Income Dynamics.

[vii] Recall that the prisoner's dilemma is a two-action version of the public goods game.

[viii] One piece of evidence for a real increase in cognitive skill: Human head size has increased by one standard deviation during the same time period when measured IQ in rich countries has increased by approximately the same amount (Jensen, 1998, p. 325).

[ix] Hunt's discussion of the James Watson affair (p. 416-417) is recommended as a dispassionate summary of an important moment in the public discussion of the possible relationship between human genetics and intelligence.