Mediators of the IQ effect on economic growth

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Abstract

The paper investigates the relationships of cognitive human capital (a.k.a. intelligence) with growth in per capita GDP between 1975 and 2009. The following results were obtained: (1) Measures of IQ and school achievement, but not length of schooling, predict economic growth; (2) IQ and school achievement are highly correlated, and can be combined into a composite measure of intelligence; (3) The combination of high intelligence and low initial per capita income is the best predictor of economic growth for both rich and poor countries; (4) Some of the effect of intelligence on economic growth is mediated by good governance; (5) Other mediators of the intelligence effect include gross domestic savings and measures of health, as well as reduced social pathologies (crime, teenage pregnancy) in advanced economies and technological sophistication and lower fertility rates in less developed countries. The results are interpreted as showing that rising intelligence, known as the Flynn effect, has been a major driver of economic growth during the last decades.

Introduction

Material wealth is considered desirable by most people. With desire for wealth rarely lacking, it is reasonable to expect that the economic success of individuals, and in consequence the economic growth of nations, is limited to some significant extent by the required cognitive skills (a.k.a. intelligence): the ability to understand the workings of the economy, and to take advantage of opportunities for personal enrichment. Based on the belief in the importance of cognitive skills, modern nations have established vast educational systems in an effort to raise children's intelligence.

Until recently, the scientific investigation of the relationship between "human capital" and economic growth has focused on measures of schooling such as average years in school and the proportion of children achieving higher educational degrees. However, what is expected to be important are the cognitive skills that children acquire in school and out of school, not their exposure to formal schooling or the diplomas they get awarded. Therefore the emphasis is rapidly shifting away from measures of exposure to formal education and towards the direct assessment of cognitive outcomes in the form of knowledge and reasoning skills.

This paper investigates two country-level measures of cognitive skills: average IQ measured by intelligence tests administered to representative samples, and results of international assessments of scholastic achievement such as PISA and TIMSS. After verifying that these

measures are indeed related to economic growth, possible mediators of the intelligence effect are investigated.

Methods

1. Measures of human capital

IQ and *School achievement* are obtained from Meisenberg & Lynn (2011). Schooling is based on the Barro-Lee data set (http://www.barrolee.com/), with missing data points extrapolated from UN and World Bank sources. *Intelligence* is a composite of these two measures, including all countries that have scores for either IQ or school achievement or both. For countries having both measures, the scores were averaged with weighting for data quality as described in Meisenberg & Lynn, 2011.

2. Measures of economic growth

GDP in 1975 and 2009 were obtained from the Penn World Tables version 7.0 (Heston, Summers & Aten, 2009), with missing data points extrapolated from the World Development Indicators of the World Bank. Economic growth was defined as the ratio between per capita GDP in 2009 and in 1975. Otherwise, per capita GDP was log-transformed because a fixed increment in an external correlate such as IQ was assumed to change per capita GDP by a constant fraction, not a constant amount.

3. Mediator variables

Whenever possible, hypothesized mediators were used from the time period between 1975 and 2009:

Government Effectiveness, *Regulatory Quality*, *Rule of Law* and *Political Stability* were from the Governance Indicators of the World Bank (www.govindicators.org), each averaged over the 1996-2005 time period.

Political Freedom was averaged from the Freedom House index of political rights and civil liberties for the years 1975-2005 (http://www.freedomhouse.org/report-types/freedom-world) and the Voice and Accountability measure of the UN Governance Indicators, 1996-2005 average. The correlation between these two measures was .916 (N = 180 countries).

No Corruption was averaged from the Governance Indicators (1996-2005) and the Corruption Perception Index of Transparency International (1998-2003, at http://www.transparency.org/research/cpi/overview), which correlate at r = .971 (N = 135 countries).

Economic Freedom (1980-2000 average) was calculated from areas 2-5 of the Fraser Institute's economic freedom index for the period 1975-2005 (www.freetheworld.com) and domains 1, 2, and 5-8 of the Heritage Foundation index of economic freedom for 1995-2005 (http://www.heritage.org/index/Download.aspx). *Big Government* was averaged from domain 1 of the Fraser Institute's index (1975-2005) and the Fiscal Policy and Government Expenditure sections of the Heritage Foundation index (1995-2005).

Welfare State is calculated from ILO (International Labour Organisation) data at http://www.ilo.org/secsoc/information-resources/WCMS_146566/lang--en/index.htm.

Gini Index is based on net income or disposable income, derived mainly from the World Income Inequality Database (WIID2a) of the United Nations University (Meisenberg, 2007).

Savings Rate is gross domestic savings, 1975-2005 average, from the World Bank at http://data.worldbank.org/indicator/NY.GDS.TOTL.ZS?page=4.

Investment %GDP, *Government %GDP*, *Consumption %GDP* and *Openness* are % of GDP spent for investment, government and consumption, and trade volume as proportion of GDP, all from the Penn World Tables 7.0 (Heston et al, 2011).

Technology is a measure computed from (1) 8 topics of the Global Competitiveness Report (GCR) 2001/02 (World Economic Forum, 2002), with missing data extrapolated from the 2010/11 GCR: unique products, sophisticated production processes, sophisticated marketing, quality of research institutions, buyer sophistication, log-transformed patents/capita, company innovation, and company R&D spending; (2) Average of log-transformed royalties/capita, patents/capita, scientific articles/capita, and books published/capita, obtained from the World Development Indicators of the World Bank and the Human Development Reports of the United Nations; and (3) the Arco technology index 1990 (Archibugi & Coco, 2004).

Life expectancy is life expectancy at birth, average of 1970-75 and 2000-05, from the Human Development Report 2005 of the United Nations (http://hdr.undp.org/en/reports/).

Infections is a measure of disability-adjusted life years lost due to infectious and parasitic diseases in 2002 (WHO, 2004).

TFR is the total fertility rate, 1975-2005 average, from the World Bank's World Development Indicators (http://data.worldbank.org/indicator).

Social Pathology is a composite measure calculated from homicide rate in 2008 from the UN Office of Drugs and Crime (http://www.unodc.org/unodc/en/data-and-analysis/homicide.html), crime victimization (stealing, mugging) from the Gallup World Poll (http://www.gallup.com/poll/world.aspx), and adolescent fertility rate from the Demographic Yearbook of the United Nations.

Statistical analysis

SPSS 16 was used. Amos 20 was used for the path models.

Results

IQ and school achievement compared

Table 1 shows the correlations of economic growth with measures of human capital and other development indicators. Only IQ and school achievement correlate significantly with growth. The correlation between IQ and school achievement is .885, suggesting that these two variables measure the same construct. The growth regressions of Table 2 show that IQ, school achievement and a composite measure of these two variables predict economic growth about equally, with little or no independent effect of schooling. A dummy for ex-communist is included because the abandonment of communism most likely has affected the growth

trajectories of these countries – negatively, according to the regressions. However, the main result is that economic growth tended to be strongest in countries that combined high intelligence with low initial per capita GDP.

Table 1. Correlations of economic growth with measures of human capital and other indicators. N = 94 countries. Correlations of IQ and school achievement with growth are significant as the p<.001 level.

	Growth	IQ	School ach.	Schooling	lgGDP	no Corr.
IQ	.419					
School Achievement	.455	.885				
Schooling	.146	.734	.726			
lgGDP 1975/2009 avg.	-.021	.670	.652	.703		
No Corruption	.102	.669	.678	.704	.754	
Political Freedom	.006	.591	.519	.642	.552	.729

Table 2. Prediction of economic growth between 1975 and 2009. Standardized β coefficients are shown. Constant (not shown) is included in the regressions. Statistical significance (2-tailed): $^{(*)}$ p<.10; * p<.05; ** p<.01; *** p<.001.

	Model 1	Model 2	Model 3
IQ	.800***		
School Achievement		.767***	
Intelligence			.800***
Schooling	.187	.082	.115
lg GDP 1975	-.747***	-.666***	-.719***
No Corruption	.217	.114	.172
Political Freedom	-.275*	-.055	-.098
Ex-Communist	-.134$^{(*)}$	-.174*	-.162*
N (countries)	110	119	135
Adj. R^2	.490	.441	.464

Use of path models

The relationships shown in Tables 1 and 2 were further explored with path models. This method tests hypothesized causal relationships explicitly, rejecting models that are incompatible with the analyzed data. Figure 1 shows the results for a "bare bones" model that predicts log-transformed per capita GDP in 2009. Abandonment of communism and log-transformed per capita GDP in 1975 are the only exogenous variables. The model shows that schooling (average years in school) is determined by lgGDP in 1975 and to a lesser extent by communist history. Intelligence (composite of school achievement and IQ) is predicted mainly

by schooling and to a lesser extent by lgGDP in 1975. The only significant effects on lgGDP in 2009 are lgGDP in 1975 and intelligence. Ex-Communist had no direct effect on intelligence both in this model and the mediator models examined in the next section. Therefore the ex-Communist → Intelligence path is omitted from all models without deterioration of the model fit. The same model fit, with RMSEA always below .001, was observed for the mediator models of Figure 2 and Table 3 as well.

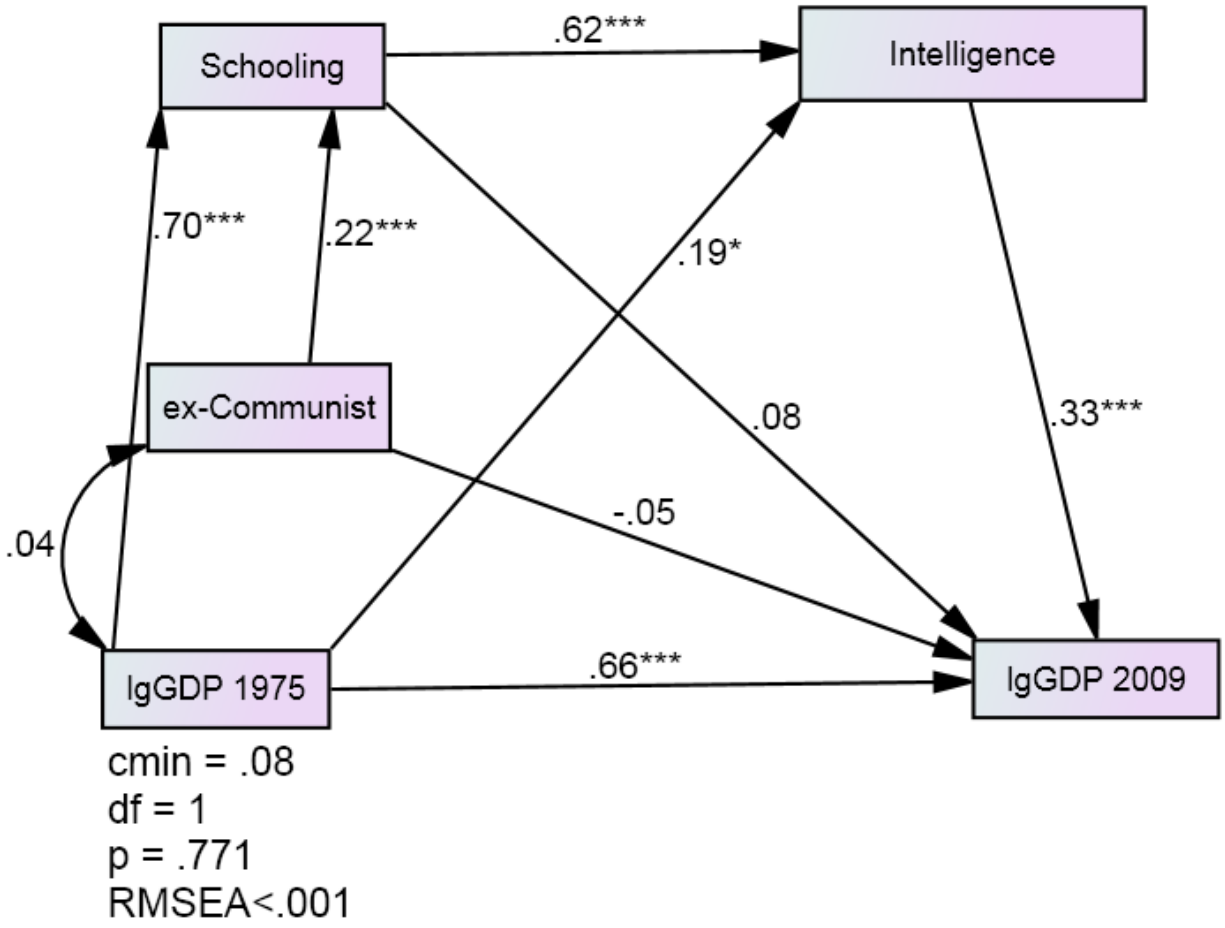

Figure 1. A path model testing hypothesized effects of predictors on log-transformed per capita GDP in 2009. N = 134 countries. * p<.05; *** p<.001.

Mediators of the intelligence effect

Hypothesized mediators of the intelligence effect were investigated with models in which the mediator was allowed to be affected by all variables except lgGDP in 2009, and to have a direct effect only on lgGDP in 2009. A variable was considered a likely mediator of the intelligence effect if (1) intelligence had a significant or marginally significant effect (p<.10, two-tailed) on the mediator, and (2) the mediator had at least a marginally significant effect on lgGDP in 2009.

Figure 2 shows an example in which the total fertility rate (TFR) is a mediator. TFR is considered a mediator because it is both reduced by high intelligence and has a significant negative effect on lgGDP 2009. The weight of the Intelligence → TFR → lgGDP 2009 path is -.47 x -.19 = .089. 26.8% of the total intelligence effect is mediated by TFR. In this example (summarized in Table 3, variable 19 all countries), the mediator (TFR) is affected by schooling as well as intelligence. Therefore it mediates effects of both variables on GDP.

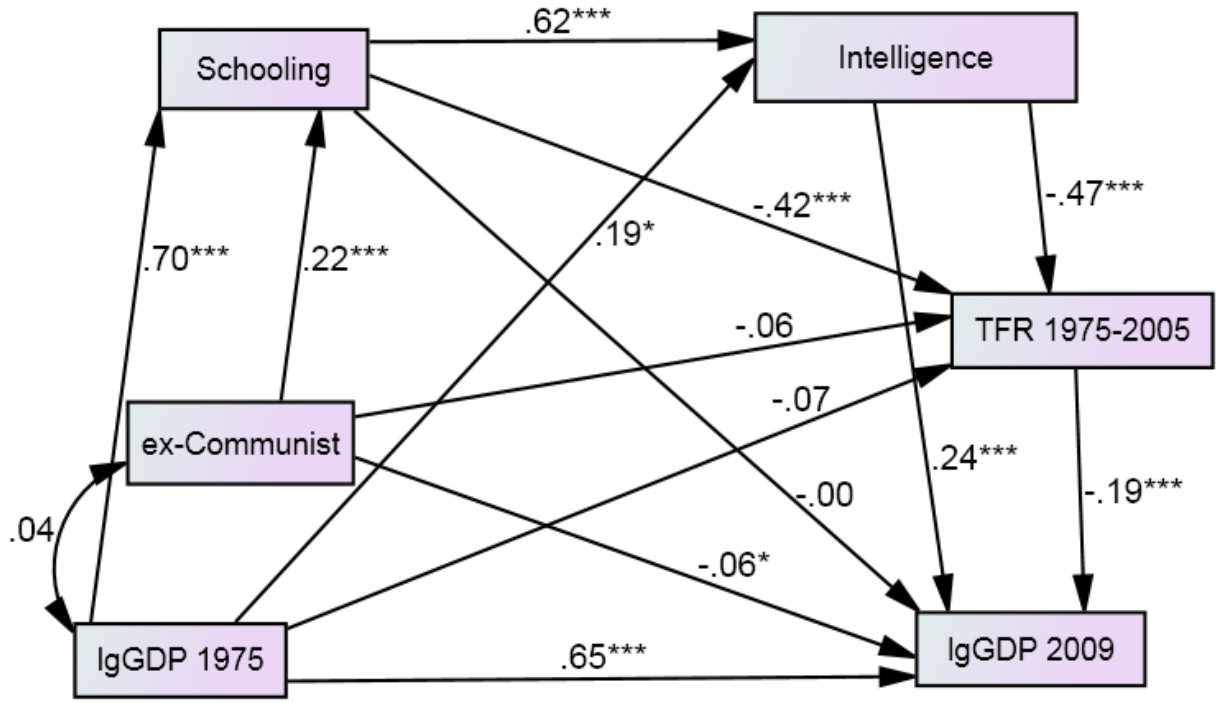

Figure 2. A path model in which the total fertility rate (1975-2005 average) mediates effects of intelligence on lgGDP in 2009. N = 134 countries. * p<.05; *** p<.001.

Table 3 summarizes the path coefficients for 21 hypothesized mediators. Models were constructed separately for the complete sample (up to 134 countries), for "rich" countries only, and for "poor" countries only (up to 67 countries each). The median split was applied on the average of log-transformed per capita GDP in 1975 and 2009. Of the 21 examined mediators, 13 were effective in the expected direction in at least one of the three groups (all countries, rich countries only, poor countries only). In only one case (variable 18, business management in poor countries) was the effect opposite, with higher IQ affecting a mediator in the direction that was detrimental to growth. The direct effect of schooling on lgGDP in 2009 was non-significant (p>.10) in 52 of the 63 models in Table 3, and significantly positive in 11. The effect of ex-Communist was non-significant in 33 models and significantly negative in 30.

Table 3. Relationships of hypothesized mediators (M) with intelligence and lgGDP 2009. Path coefficients are shown (see Figure 2). Intelligence is average of IQ and school achievement. % Indirect is the percentage of the total IQ effect on lgGDP 2009 that is apportioned to the path through the mediator. Significance levels (2-tailed): $^{(*)}$ p<.10; * p<.05; ** p<.01; *** p<.001.

Countries	Intelligence → M	M → lgGDP09	Intelligence → lgGDP09	% Indirect
1. Economic Freedom				
All	.199*	.056	.315***	3.4
Rich	.457***	.164*	.380***	16.5
Poor	-.227$^{(*)}$	.144*	.482***	-7.3
2. Political Freedom				
All	.130	.066*	.318***	2.6
Rich	.229*	.077	.437***	3.9
Poor	-.188	.166**	.480***	-7.0
3. *No Corruption*				
All	.350***	.088*	.296***	9.5
Rich	.449***	.257**	.340***	25.3
Poor	.058	.194***	.438***	2.5
4. Political Stability				
All	.241*	.116***	.299***	8.6
Rich	.397***	.259***	.352***	22.6
Poor	.011	.164**	.447***	0.4
5. Government Effectiveness				
All	.402***	.155***	.264***	19.1
Rich	.484***	.311**	.305***	33.0
Poor	.219$^{(*)}$	.306***	.382***	14.9
6. Regulatory Quality				
All	.321***	.155***	.277***	15.2
Rich	.456***	.229**	.350***	23.0
Poor	.036	.305***	.438***	2.4
7. Rule of Law				
All	.381***	.155***	.268***	18.1
Rich	.498***	.341***	.285***	37.4
Poor	.130	.284***	.412***	8.2
8. Gini Index				
All	-.685***	-.042	.298***	8.8
Rich	-.481***	-.157	.380***	16.6
Poor	-.552***	-.126$^{(*)}$	.379***	15.5

Table 3 continued

Countries	Intelligence → M	M → lgGDP09	Intelligence → lgGDP09	% Indirect
9. Social Pathologies (crime, teen pregnancy)				
All	-.727***	-.047	.293***	10.4
Rich	-.681***	-.258**	.279**	38.6
Poor	-.651***	-.057	.412***	8.3
10. Welfare State				
All	.354***	.009	.324***	1.0
Rich	.381***	-.044	.472***	-3.7
Poor	.273***	.073	.429***	4.4
11. Trade Openness				
All	.086	.063*	.321***	1.7
Rich	.169	.226***	.417***	8.4
Poor	-.005	-.033	.449***	0.0
12. Technology				
All	.331***	-.009	.330***	-0.9
Rich	.397***	-.011	.459***	-1.0
Poor	.191*	.275**	.396***	11.7
13. Gross Domestic Savings				
All	.249*	.094**	.303***	7.2
Rich	.134	.216***	.426***	6.4
Poor	.367**	.087	.417***	7.1
14. Consumption share of GDP				
All	-.111	-.052(*)	.321***	1.8
Rich	.027	-.239***	.461***	-1.4
Poor	-.256(*)	.002	.450***	-0.1
15. Investment Share of GDP				
All	.198	.066**	.314***	4.0
Rich	.242(*)	.053	.442***	2.8
Poor	.196	.153*	.419***	6.7
16. Government Share of GDP				
All	-.018	-.016	.326***	0.1
Rich	-.311*	-.009	.452***	0.6
Poor	.092	-.033	.452***	-0.7
17. Big Government				
All	-.033	-.041	.325***	0.4
Rich	-.017	-.059	.454***	0.2
Poor	-.093	-.051	.444***	1.1

Table 3 continued

Countries	Intelligence → M	M → lgGDP09	Intelligence → lgGDP09	% Indirect
18. Business management				
All	.094	.046	.322***	1.3
Rich	.221*	.143	.423***	7.0
Poor	-.305*	.195**	.508***	-13.3
19. Total Fertility Rate (TFR)				
All	-.469***	-.187***	.239***	26.8
Rich	-.512***	-.083	.413***	9.3
Poor	-.460***	-.319***	.302***	32.7
20. Infectious Diseases				
All	-.605***	-.101**	.266***	18.7
Rich	-.648***	-.073	.408***	6.7
Poor	-.629***	-.073	.368***	18.0
21. Life Expectancy				
All	.419***	.149*	.264***	19.1
Rich	.553***	.108	.395***	13.1
Poor	.479***	.130	.387***	13.9

Discussion

IQ and school achievement

The first notable result of this study is the apparent equivalence of IQ, measured with intelligence tests, and school achievement, measured with assessments in curricular subjects such as mathematics, science and reading. At the country level, these measures are highly correlated and have virtually the same correlates with other social, political and economic variables including economic growth. Therefore they can be averaged into a single measure of intelligence, which is available for a larger number of countries when countries with information on one of the two measures are included. We have data on IQ for at least 138 countries and school achievement for 149 countries. 109 countries have data for both, and 178 have data for either IQ or school achievement or both (Meisenberg and Lynn, 2011; Lynn & Vanhanen, 2006, 2012; data available on request from the author).

Uncertain causality

One important issue concerns the time periods for which the results are available. The IQ measure is based on studies published from the 1930s to 2012, with a median date of 1990. Most of these studies were performed with children or adolescents. Therefore IQ studies performed during the 1960s would, in theory, be an optimal measure for the cognitive skills of the adult work force between 1975 and 2009. However, studies from this time are available for only a few countries and are not always of good quality. The IQ data set includes a "one size fits all" correction for the secular rise of intelligence that became known as the Flynn effect.

Although the strength of Flynn effects has been different in different countries (Flynn, 1987, Meisenberg & Woodley, 2013), the errors introduced by the assumption of uniform IQ gains are most likely mild.

Most of the data that were computed into the school achievement measure are from the PISA studies of 2000-2009 and the TIMSS studies of 1995-2007, which were conducted with 15-year-olds (PISA) and 8th graders (TIMSS). Again, we have to assume that differences in national achievement levels are relatively stable over time periods of 2 to 3 decades if we want to accept results on these scholastic assessments as measures of the cognitive skills that have driven economic growth between 1975 and 2009. The alternative explanation, that intelligence is a consequence but not a cause of economic growth, cannot be excluded. However, this is unlikely because the important relationship of the intelligence measures is not with cross-sectional per capita GDP, but with the *change* of per capita GDP over time. Although the correlations of the intelligence measures are lower with economic growth than with static per capita GDP (Table 1), the former relationship is more robust to the inclusion of other predictors, such as the ones included in Tables 1, 2 and 3.

Mediation effects

The path models that were employed in this study tackle the endogeneity problem by modeling intelligence both as an effect of material wealth at an earlier time and a cause of wealth at a later time, assuming that the intelligence measure is a reasonably accurate representation of the prevailing intelligence level during the intervening time period. Although the path models are structurally different from the growth regressions in predicting GDP at the later time point rather than a change score, the important results are virtually the same: GDP at the earlier date and intelligence have robust effects, with only minor effects of other variables.

Some of the mediator variables were chosen because they have well-established relationships with intelligence at the country level (e.g., Gini index, Meisenberg 2007, 2008a) or the individual level (e.g., crime and teenage pregnancy, Herrnstein and Murray, 1994). Others were chosen because of their known or hypothesized relationships with economic growth. As expected, none of the chosen mediator variables explained more than a modest fraction of the intelligence effect. There were, however, some characteristic patterns:

1. Measures of governance (political stability, government effectiveness, freedom from corruption, regulatory quality, rule of law, variables 3-7 in Table 3) consistently predict economic growth in both rich and poor countries. Most of these measures have previously been found to be associated with intelligence (Kalonda-Kanyama and Kodila-Tedika, 2014). The present results show that they are affected by intelligence in rich countries but possibly not in poor countries. The reasons for the latter observation are unknown but may be related to uncertain data quality from many of the poorer countries. These five governance indicators are highly correlated for the 134 countries in the complete sample, with Pearson's *r*'s between .747 (corruption and political stability) and .963 (government effectiveness and rule of law). They should therefore be interpreted as different facets of a single underlying dimension, which we can describe as "good government."
2. Economic freedom, here defined as freedom from excessive regulation and red tape for businesses (variable 1 in Table 3), does mediate some of the IQ effect in rich countries. This

variable is highly correlated (Pearson's r's>0.80) with all governance indicators except political stability, and can be considered another measure of "good government."

3. Unlike "good government," measures of "big government" (variables 16 and 17 in Table 3) are barely affected by intelligence, nor do they have robust effects on economic growth. The latter effect is not surprising because earlier studies (reviewed in Guseh, 1997) have produced contradictory results. Also the presence of an extensive welfare state, measured as resources allocated to pensions, unemployment compensation, health care and other social services (variable 10 in Table 3), is not an important mediator of the IQ effect because it has no major impact on economic growth.
4. Good business management, or "managerial capital," (Bloom, Mahajan, McKenzie & Roberts, 2010; Bruhn, Karlan & Schoar, 2010) is another obvious candidate. The measure used here (variable 18 in Table 3), composed of reliance on professional management and delegation of decision making, is best understood as a measure of trust in business managers, or of managers' trustworthiness, because the alternatives – reliance on the owner's relatives and centralized decision making – are expressions of distrust (Bloom et al, 2010). The results presented in Table 3 are inconclusive. The observation that presumed "good management" is predicted by low rather than high intelligence in poor countries is difficult to explain.
5. Social pathologies (crime, teenage pregnancy) and income inequality (variables 8 and 9 in Table 3) are known to have robust negative correlations with intelligence at the country level (e.g., Meisenberg, 2007, 2008a). Both measures tend to be associated with slower economic growth and therefore may mediate some of the effects of intelligence on economic growth. They are highly correlated with each other at the country level (r = .677, N = 131 countries), and high income inequality is sometimes considered a cause of social pathologies including crime and teenage pregnancy (e. g., Wilkinson & Pickett, 2009). It is uncertain whether higher IQ reduces income inequality by market forces, more effective systems of wealth redistribution, or some other mechanism.
6. Allocation of capital resources was hypothesized as being important because higher intelligence is associated with lower impulsivity and lower time preference at the individual level (Shamosh & Gray, 2008). The expectation is that this relationship is manifested as higher savings rates, lower consumption and higher investment rates in countries with higher average intelligence. Variables 13-15 do indeed show a trend in the predicted direction. The effects are weak and inconsistent, and appear to mediate only a small fraction of the IQ effect at best.
7. Also technological competitiveness and trade openness (variables 11 and 12 in Table 3) appear to be of limited importance. Trade openness favors economic growth in rich but not poor countries, suggesting that the terms of international trade may be systematically favoring the more prosperous countries. Technological competitiveness is favored by higher intelligence as expected (Gelade, 2008). However, it has a positive impact on economic growth only in poor but not rich countries. This suggests that technology diffusion from the technological frontier is important for economic development of the less developed countries, whereas innovation no longer contributes to rising prosperity in the most advanced nations.

8. Total fertility rate (TFR, variable 19 in Table 3) is another measure that is known to be strongly affected by intelligence at the country level, independent of other development indicators (Meisenberg, 2009). Table 3 shows that high fertility has little effect on economic growth in prosperous countries, but up to one third of the intelligence effect in poor countries appears to be mediated by lower fertility. This result is unsurprising for those who see Malthusian pressures as a major threat to developing countries (e.g., Clark, 2007). However, a young age structure resulting from high fertility is also expected to create a young, vigorous and innovative work force that drives economic development (Headey & Hodge, 2009). The main reason for the detrimental effect of high fertility may well be that the relationship between fertility and education is negative world-wide. This fertility differential tends to be strongest in less developed countries (Meisenberg, 2008b). Therefore the excess fertility is contributed mainly by less educated parents. In this setting, high fertility is expected to contribute to economic retardation even in the absence of Malthusian pressures. The importance of the quality as well as the quantity of the human population has been emphasized, for example, by Lutz (2009).
9. Health indicators in general are highly correlated with intelligence at the country level, as shown for variables 20 and 21 in Table 3. It is also evident that better health, operationalized here by lower rates of infectious and parasitic diseases and higher life expectancy, appears to mediate a modest fraction of the intelligence effect on economic growth, confirming results of earlier work (Beraldo, Montolio & Turati, 2009).

The conclusion we can draw from these results is that intelligence influences economic growth through multiple channels. Good government, better health care, as well as reduced fertility and perhaps increased ability of technology absorption in poor countries appear to be most important.

Concluding Remarks

The observation that a mismatch between intelligence and pre-existing wealth is the most important predictor of economic growth begs the question of why such mismatches exist in the first place. If intelligence is constant over time and if it drives economic growth by any or all of the mechanisms investigated in this study, such mismatches would be erased fast.

The reason why these mismatches still exist is that intelligence is not constant. It can rise (and potentially fall) by something like 30 IQ points in a single century (Flynn, 1987). The countries that had achieved high intelligence by the end of the 20th century, when most of the cross-national intelligence measures were taken, are those that had experienced strong intelligence gains during the preceding one or two centuries. These intelligence gains were both cause and consequence of the economic gains taking place at the same time, as modeled in Figures 1 and 2. Today, intelligence appears to be leveling off in the most advanced nations, most likely because biological limits prevent further gains, while intelligence is rising in the less developed countries (reviewed in Meisenberg & Woodley, 2013). This development predicts a combination of economic stagnation in the most advanced countries and continued growth in the less developed countries, until the biological limits of intelligence will be reached in the latter countries as well. Thus the correlation between intelligence and economic growth will

turn from positive to negative. This development is foreshadowed by the economic advances that many African countries have made since the 1990s (Sala-i-Martin & Pinkovskiy, 2010).

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