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**Schooling, Labour Force Quality and the Growth of
Nations: Comment**

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Abstract

Hanushek and Kimko (2000) concluded that, for a sample of nearly 80 countries, the quality of the labour force is significantly positively related to economic growth rates for the period 1960-1990 and is more important than mean years of schooling. In this paper, we further test the robustness of their result by firstly including in the original model a proxy for labour force health, and secondly by re-estimating the model for a later sample period. We conclude that the findings of Hanushek and Kimko are not robust to these changes. In particular, their measure of labour force quality is significantly but negatively related to economic growth rates for the later sample period.

JEL codes: O47, C21

Introduction

In an earlier article in this *Review*, Eric Hanushek and Dennis Kimko (2000) investigated the sources of differences in the mean economic growth rates of a sample of countries by accounting for the quality of their labour forces. Hanushek and Kimko (hereafter, HK) combined the results from 6 international studies of the mathematics and science understanding of students aged between 9 and 17 years and conducted between 1965 and 1991 into a single measure of labour force quality for each country. Whilst the maximum number of countries that participated in any individual test was less than 40, HK expanded the sample size to 90 by normalising the observed test scores, regressing these on country specific economic and other characteristics such as parental education and public education spending per student, and then imputing test scores for other, non-participating countries. With this new explanatory variable added to other commonly used variables such as initial per capita incomes, years of schooling completed and population growth rates, HK found that “Labour force quality is significant with the correct sign even when school quantity tends to lose significance. The quality measures are also quite robust in the Levine and Renelt (1992) sense of being impervious to the precise empirical specification” (p.1185). HK's only caveat concerns the magnitude of their estimate of the impact of labour force quality on growth, which is much larger than deemed plausible.

In this paper we ask and attempt to answer two questions. Firstly, how do HK's results change with the inclusion of a proxy for the health of the labour force in each country as an additional human capital variable? Recent studies have shown that health is positively related to growth and that the inclusion of health substantially reduces the marginal impact of education. However, most such studies typically use only years of schooling to proxy for

education. Hence we investigate whether health is still important for growth whilst controlling for both years of schooling and the cognitive abilities of students. Secondly, do HK's conclusions stand for a later sample period? HK assume that the mean cognitive abilities of students measured between 1965 and 1991 are good indicators of the quality of the labour force, and hence should help explain differences in economic growth rates, over roughly the same period, because of the presumption that "...schooling systems evolve slowly over time, in part related to the stationarity of the teaching technology and to the slow turnover of teachers and other personnel" (p1186). Hence HK assume that countries with high (low) achieving students during 1965-1991 were also likely to have had high quality workers over this period because those workers were likely to have been high (low) achievers when they themselves were students. So working forward, we assume that high (low) achieving students in the period 1965-1991 are also likely to subsequently end up as high (low) quality workers. We thus also investigate whether HK's labour force quality measures are important for growth, but for the period 1985-1998.

Our results lead us to the following conclusions. Firstly we find that labour force health is important for growth and that the inclusion of health reduces substantially the magnitude of the impact of labour force quality on growth for the period 1960-1990. Hence labour force health appears to be an important human capital variable omitted in HK. We also find that HK's measure of labour force quality performs poorly in growth regressions for the period 1985-1998, whereas labour force health continues to be important for growth.

I Hanushek and Kimko's Results

Between 1965 and 1991 the IEA (International Association for the Evaluation of Educational Achievement) and the IAEP (International Assessment of Educational Progress)

conducted six tests of the cognitive abilities of upper primary and secondary school students in mathematics and science in a total of 38 countries (see Beaton, *et. al*, 1996a and 1996b). HK use the information provided by these tests to construct two highly correlated measures of labour force quality for each of the countries that participated in at least one test. After conducting some preliminary growth regressions with this rather small data set (see HK Table 2), the authors regress their labour force quality measures on a number of plausible country specific explanatory variables and then use the results to project labour force quality for other, non-participating countries, ending up with data on 90 countries. Growth regressions with this expanded sample reinforce the earlier results. Table 1 presents their main findings. According to HK, "A one standard deviation change in quality translates into a slightly greater than one percentage-point difference in annual real growth rates. The effect of quality improvements also appears much more important than increases in quantity: a one standard deviation change in school quantity translates into 0.32 percentage points in average growth..." (p.1196).

Table 1: labour force quality and economic growth in HK: 1960-1990
(dependent variable: average annual growth rate of real per capita GDP x 100)

Variable	(1)	(2)
IY ('000's \$)	-.39 (.079)	-.38 (.082)
EA (years)	.117 (.093)	.103 (.10)
PGR (%)	-.097 (.212)	-.161 (.209)
QL1	.104 (.023)	
QL 2		.09 (.016)
Sample Size	78	80
R Square	.42	.41

Note: Huber-White estimated standard errors are in parentheses. Results in column (1) are from HK Table 5 column 2 whilst those in column (2) are from HK Table 5 column 5. IY is the initial level of real per capita income in thousands of dollars. EA is mean years of educational attainment of the population aged 25 years and above. PGR is the annual geometric rate of population growth expressed in percentage terms. QL1 and QL2 are measures of labour force quality from HK.

HK go on to investigate the earnings of US immigrants educated either in their country of birth or in the US to determine whether their results are driven by some omitted country specific variable and conclude that this is not the case, but rather that their quality measures do indicate differences in labour force productivities across countries. They also test the sensitivity of their results to influential observations by re-estimating their baseline growth regressions but on samples that exclude various combinations of fast growing Asian countries, again concluding that labour force quality is important for growth. Their only concern, one that remains unresolved, is with the large impact that their quality measure has on growth, with a one standard deviation increase in labour force quality having the same impact on growth as would be obtained from over nine additional years of average schooling.

HK further tested, in unreported regressions, the sensitivity of their results by adding to their baseline model other economic measures that have been found to be important for growth, such as the ratio of government consumption expenditure net of defence and education spending to GDP, the ratio of private investment to GDP, and the ratio of total trade to GDP, but concluded that labour force quality remains important. So as far as we can make out, HK ignored labour force health as an additional explanatory variable. Thus in the next section we re-examine the issue of robustness by including in the model a proxy for labour force health.

II The Impact of Health on the Results of HK: 1960-1990

HK's empirical approach is based on endogenous growth theory, where country i 's mean rate of economic growth (g_i) is a function of the quality of its' labour force (QL_i) and a vector of other explanatory variables (X_i) as follows (see HK equation 1):

$$g_i = aQL_i + bX_i + e_i \quad (1)$$

We wish to determine whether HK's results are robust to the inclusion of a proxy for labour force health¹. A number of recent studies have concluded that the health of the population, and hence of workers, is an important determinant of economic performance. For instance, Barro and Sala-i-Martin (1995) found that for a large number of countries, their proxy for health has a strong positive relationship with growth "...because it proxies for features other than good health that reflect desirable performance of a society, (such as) better work habits and a higher level of skill" (p.432, see also McDonald and Roberts 2002, Sen 1998 and Knowles and Dorian Owen 1997). In line with other studies we define health ($H_{i,t}$) for country i at time t as a function of the shortfall of life expectancy at birth ($LE_{i,t}$) from a nominal benchmark, as follows, and include this in our estimation of equation (1):

$$H_{i,t} = -\ln(80-LE_{i,t}) \quad (2)$$

HK estimated (1) by assuming a linear functional form with additive effects of educational achievement and labour force quality but note that "The substitution of logarithmic models....yielded virtually identical qualitative results..." (p.1190). On theoretical grounds, we prefer to estimate (1) with all variables in natural logarithms as this functional form better

¹ Model selection tests (Akaike Information Criterion and Schwarz Criterion) on OLS regressions of equation (1) indicate that the inclusion of health results in an improved specification. The simple correlation coefficient between health and labour force quality is 0.72 suggesting the likelihood of multicollinearity (t-statistic = 9.04, critical value for 2 sided test, with 85 df's at the 1% level = 2.64). However, some of the variables used in HK are also highly correlated. For instance, the simple correlation coefficient between initial incomes and years of educational attainment is 0.80. In any case, dropping a theoretically relevant variable may result in the more serious problem of misspecification bias.

captures the likely relationships between economic growth rates and each of the explanatory variables. In any case we report estimation results for (1) in both linear and double-log form.

HK constructed two measures of labour force quality for up to 90 countries (see QL1 and QL2 in their Table C1, Appendix C). As these two measures are highly positively correlated ($r=.95$), we use HK's second measure only (QL2) as our proxy for labour force quality as this covers a slightly larger sample of countries. Using data from the Penn 5.6 database, Barro and Lee (2000) and the World Bank, we constructed data for 87 of the 90 countries for which a QL2 score in HK exists, omitting only Bahrain, Iraq and Kuwait because of data limitations. Table 2 presents summary statistics for the variables used in this section (the data is available from the author on request) whilst Appendix A contains explanatory notes on data sources and construction methods.

Table 2: summary statistics for variables used to estimate equation (1): 1960-1990

<i>Variables</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>
EGR (%)	2.35	1.71	-1.39	6.66
IY ('000's \$)	2815	2357	313	9895
PGR (%)	1.82	0.98	0.10	3.66
EA (years)	4.63	2.54	0.43	10.37
QL2	45.92	12.85	18.26	72.13
LE (years)	64.07	9.1	44	76

Notes: EGR is the annual geometric rate of growth of real per capita GDP expressed in percentage terms. LE is years of life expectancy at birth. Other variables are as previously defined. See Appendix A for full explanatory notes and data sources.

HK run OLS regression and attempt to control for influential observations by omitting various subsets of the faster growing East Asian economies that also scored highly on the international tests and then re-estimating. However, some economies collapsed

during the sample period and also performed poorly on the international tests, for instance the Central African Republic, Mozambique and Nicaragua, and so these could also be influential observations. Rather than omitting various subsets of countries and re-estimating, we control for influential observations by running median regressions, a statistical technique that minimises the absolute deviation around the median of the distribution of the dependent variable rather than the mean and thus results in an estimator that is not sensitive to outlier observations on the dependent variable (see Buchinsky 1998). Our estimation results for the period 1960-1990 are in Table 3.

Table 3: cross-country growth models: 1960-1990 (dependent variable: % annual geometric growth rate in real per capita GDP x 100).

<i>Variables</i>	<i>(1) linear</i>	<i>(2) linear</i>	<i>(3) log-log</i>	<i>(4) log-log</i>
IY ('000's \$)	-0.37 (-3.65)	-.44 (-4.97)	-.32 (-4.65)	-.43 (-5.68)
PGR (%)	-.50 (-2.39)	-.22 (-1.17)	-.66 (-3.69)	-.57 (-3.22)
EA (years)	.15 (1.17)	.02 (.17)	.23 (2.22)	.10 (.97)
QL2	.05 (3.19)	.05 (3.71)	.45 (2.44)	.30 (1.70)
H		1.15 (2.92)		.41 (3.15)
Constant	1.21 (1.27)	4.52 (2.97)	-.72 (-1.06)	1.07 (1.27)
n	87	87	87	87
Pseudo R ²	0.36	0.45	0.33	0.43

Notes: all variable are as previously defined. t-statistics are in parentheses besides each coefficient estimate. All estimates are from median regressions. The results in columns 3 and 4 are with all variables expressed as natural logarithms, except the dependent variable which is defined as the log difference in real per capita GDP from 1990 to 1960, and the population growth rate which is defined as the log difference in population from 1990 to 1960.

In column (1), the linear model without health, the sample displays strong conditional convergence. A significant inverse relationship exists between economic and population growth rates, labour force quality is significant in the expected direction and years of schooling has the expected sign but is not significant at usual confidence levels. Apart from the significance of population growth, these results are consistent with those of HK (see their Table 5 column 5). When we add health in column (2), conditional convergence

remains strong, population growth rates are no longer significant and labour force quality remains significant in the expected direction. Labour force health is also significant and positively associated with economic growth rates. So in the linear specification, whilst health is significant and positively associated with growth, its inclusion does not diminish the importance of labour force quality.

However, the results change somewhat when we estimate the model in double-log form. In column (4) conditional convergence is still strong, population growth is still bad for economic growth whilst health remains important and in the expected direction. But now neither years of schooling nor labour force quality are significant. Finally, we note that in both the linear and logarithmic estimates, health has a bigger impact on economic growth than does labour force quality. For instance, in column (4), a one standard deviation change in health results in a 0.8 percentage point change in mean annual growth rates whereas the equivalent impact of labour force quality is 0.3 percentage points of annual growth.

Clearly, HK's results for labour force quality are not robust to changes in functional form nor, in the double-log model, to the inclusion of labour force health as an additional explanatory variable, which reduces substantially the magnitude of the impact of labour force quality. Thus it seems that HK have overlooked an important human capital variable that helps to explain differences in economic growth rates across countries for the period 1960-1990. In the next section, we investigate the relationship between economic growth, labour force quality and health but for a later period.

III Health, Labour Force Quality and Economic Growth: 1985-1998

In this section we test whether HK's measure of labour force quality for the period 1965-1991 helps to explain differences in economic growth rates for the period 1985-1998.

We hypothesise that if a measure of the cognitive ability of young students at time t is a good predictor of the contemporaneous quality of workers then, working forward, the same measure should also be a good predictor of the quality of workers at time $t+1$. Hence current period cognitive abilities ought to be positively related to future economic growth also.

We selected the period 1985-1998 in part to suit the availability of data but also because a lag of about two decades between the measured cognitive abilities of young student and their subsequent contribution to national product seems reasonable. As our data on educational attainment, the other schooling related variable, is for the population aged 25 years and above we maintain the approach of HK and regress the mean economic growth for 1985-1998 on contemporaneous mean years of educational attainment, as well as contemporaneous population growth rates and labour force health. Because the USSR and Yugoslavia underwent major political upheaval in the early 1990's, and because of some other data limitations, our sample size for this section is reduced to 83. Table 4 presents summary statistics (again, this data are available from the author on request) whilst our estimation results are in Table 5. Notes on data sources and construction methods for this period are also in Appendix A.

Table 4: summary statistics for variables used to estimate (1): 1985-1998

<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Minimum</i>	<i>Maximum</i>
EGR (%)	1.60	2.2	-3.57	6.42
IY ('000's \$)	8338	6625	669	24632
PGR (%)	1.55	0.96	-0.35	4.2
EA (years)	6.29	2.57	0.91	12.04
QL2	45.65	13.01	18.26	72.13
LE (years)	66.69	8.65	44	78

Notes: all variables are as previously defined but for the period 1985-1998, except for QL2 which is HK's measure of labour force quality for the period 1965-1991.

Table 5: cross-country growth models: 1985-1998 (dependent variable: % annual geometric growth rate in real per capita GDP x 100)

<i>Variable</i>	<i>(1) linear</i>	<i>(2) linear</i>	<i>(3) log-log</i>	<i>(4) log-log</i>
IY ('000's \$)	-.08 (-1.83)	-.21 (-4.11)	-.09 (-1.96)	-.17 (-3.32)
PGR (%)	-.77 (-3.30)	-.53 (-2.21)	-1.00 (-4.02)	-.91 (-3.82)
EA (years)	.23 (1.77)	.16 (1.17)	.20 (2.33)	.20 (2.37)
QL2	-.004 (-.21)	-.02 (-.77)	-.12 (-1.10)	-.22 (-2.21)
H		1.90 (3.76)		.16 (2.43)
Constant	2.02 (2.01)	8.39 (4.27)	.62 (1.64)	1.54 (3.40)
n	83	83	83	83
Pseudo R ² (?)	.23	.27	.23	.22

Notes: all variable are as previously defined. t-statistics are in parentheses besides each coefficient estimate. All estimates are from median regressions. The results in columns 3 and 4 are with all variables expressed as natural logarithms, except the dependent variable which is defined as the log difference in real per capita GDP from 1998 to 1985, and the population growth rate which is defined as the log difference in populations from 1998 to 1985.

Once again we note the dominance of health over labour force quality in these results. In column (2) our sample displays strong conditional convergence, population growth is significant and inversely related, whilst health is significant and positively related, to economic growth. In this linear model neither years of educational attainment nor labour force quality are significant, with the coefficient estimate on the latter actually being negative. With the logarithmic model the results are even more surprising. In column 4 conditional convergence remains, as does the adverse impact of population growth. But now years of educational attainment are positively, whilst labour force quality is negatively, associated with economic growth, both being statistically significant. Once again the relationship between health and economic growth remains significant and in the direction expected, with a one standard deviation increase in (the natural logarithm of) health resulting in a 0.9 percentage point increase in the mean annual growth rate over this period.

IV Discussion

Our results indicate clearly that, across both sample periods, labour force health is important for economic growth. But how are we to make sense of the results for labour force quality in Table 5? One possibility is that the much publicised 'new economy' of the last decade has resulted in a more rapid depreciation of the cognitive abilities of workers that, for an earlier generation, were indicators of high subsequent labour productivity. However, this hypothesis has a number of problems. Firstly, the tests were of abilities in basic mathematics and science, and it is not clear why these skills should be less important in the 'new economy' than they were in the 'old'. Secondly, whilst this explanation may help explain why countries with high cognitive achievement experienced lower rates of growth in the later period, it does not explain why countries with low cognitive achievement experienced faster rates of growth, other things equal. It seems highly unlikely that schools in low achieving countries have for the past 40 years been teaching to some alternate curriculum that has resulted in their students achieving low scores in tests based on the 'old' curriculum, but that has subsequently proven beneficial for economic growth.

A more likely explanation is that our results for labour force quality for the period 1985-1998 are driven by the strong conditional convergence displayed by the data. Barro and Sala-i-Martin (1995) found that female years of schooling are negatively and significantly associated with economic growth rates for the period 1960-1990 and suggested that this puzzling result was due to countries with low female schooling also being the initially poorest ones. Hence with strong conditional convergence, the initially poorest countries, and thus those with the lowest levels of female schooling, subsequently grew most quickly. So perhaps a similar explanation holds in this case. Countries with the lowest levels of cognitive

achievement were also the initially (in 1985) poorest ones who, because of the convergence phenomenon, subsequently grew most rapidly. This explanation is supported by the high simple correlation coefficient between initial income levels and labour force quality in our data ($r_{Y85, QL2} = .63$, t-statistic = 7.30, critical value at 5% level of significance, one sided test with 81df = 1.66).

One potential problem with this explanation is that conditional convergence is also a strong feature in the data, yet labour force quality is positively related to growth, for the period 1960-1990 . But this may be because the correlation between initial incomes and labour force quality for this period was much weaker ($r_{Y60, QL2} = .46$). Hence it is possible that our results for labour force quality in Table 5 are driven by the strong conditional convergence displayed by our data. Of course we may now ask why the positive correlation between initial incomes and cognitive abilities became greater in this later period, and whether this is suggestive of a more rapidly changing teaching technology than had previously been the case. This question is the subject of ongoing research.

V Concluding Comments

HK investigated the determinants of differences in economic growth rates by, perhaps for the first time, accounting for differences across countries in the cognitive abilities of school students. Their attempt to control for the actual learning that takes place at school is intuitively appealing and fills a gap that has existed in many previous studies of economic growth that have relied heavily or solely on years of schooling as the relevant human capital variable. However, HK's conclusion, that their measure of labour force quality is important for growth, that it remains so in the presence of other commonly used variables, and that it is

much more important than years of schooling alone, is not robust in this study to the inclusion of a proxy for labour force health nor to a change in the functional form. Furthermore, the measured cognitive abilities of students for the period 1965 to 1991 enters significantly into growth regressions for the period 1985-1998 but with the wrong sign, whilst health and years of schooling are significant and in the expected direction.

Our results, whilst tentative because of the usual caveats concerning data quality and construction, empirical specification, and so on, nevertheless reinforce the findings of other studies on the existence of a strong positive relationship between the health of a country's population and thus labour force, and the rate at which their real incomes increase over time. More importantly for this study, our results suggest that the relationship between the measured cognitive abilities of students as a proxy for the quality of the labour force, and contemporaneous and subsequent economic growth may be more fragile than appears to be the case in HK.

Appendix A

Data for Growth Regressions: 1960-1990

EGR and PGR are the geometric annual growth rates of real per capita real GDP and population, respectively, for all countries for the period 1960-1990 except for Botswana, Zaire, Swaziland, Malta, USSR and Barbados, where the relevant period is 1960-1989, and Hungary and Poland, where the relevant period is 1970-1990.

IY is the level of real per capita GDP in 1960 for all countries except Hungary and Poland, where it refers to 1970.

All data on real per capita GDP and population are from the Penn5.6 database.

EA refers to the arithmetic mean of the mean years of educational attainment, for the total population aged 25 years and over, in 1960, 1965, 1970, 1975, 1980 and 1985, except for China, Congo and Egypt where it refers to the arithmetic mean of the mean years of educational attainment in 1975, 1980 and 1985 only, and will thus be biased upwards. EA for Luxembourg was calculated as the arithmetic mean of the educational attainment figures for Belgium, Germany and France, whilst the figure for Nigeria was assumed to be identical to that of Cameroon. Data on educational attainment are from Barro and Lee (2000).

QL2 is a proxy for labour force quality from Hanushek and Kimko (2000).

H is a proxy for labour force health and was calculated as follows: $H = -\ln(80 - LE_{77})$ where LE_{77} is life expectancy in years in 1977, the earliest year for which complete data on life expectancy exists for our sample of countries. Data on life expectancy are from the World Bank.

Data for Growth Regressions: 1985-1998

EGR and PGR are the geometric annual growth rates of real per capita GDP and population, respectively, for all countries for the period 1985-1998. IY is the level of real per capita GDP in 1985. All data on real per capita GDP and population are from the Penn 6.0 database. EA refers to the arithmetic mean of the mean years of educational attainment, for the population aged 25 years and over, in 1985, 1990, 1995 and 2000, for all countries except Luxembourg, whose EA figure was calculated as the arithmetic mean of the educational attainment figures for Belgium, Germany and France, and Nigeria whose EA figure was assumed to be identical to that of Cameroon.

All data on years of educational attainment are from Barro and Lee (2000).

In the case of Germany (united), we used the income per capita growth rate for the period 1991-1998 whilst the educational attainment figure is the mean of the figures for 1990, 1995 and 2000.

QL2 is a proxy for labour force quality from HK (2000).

H is a proxy for labour force health and was calculated as follows: $H = -\ln(80 - LE85)$ where LE85 is life expectancy at birth in 1985, for all countries except Taiwan where the relevant figure was assumed to be identical to that of Korea.

All data on life expectancy at birth are from the World Bank.

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